BULLETIN OF UNDERGRADUATE STUDIES

1976-1978

COLLEGE OF PURE AND APPLIED SCIENCES

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Prospective applicants for admission will find it helpful to first refer to sections of the *Admissions Regulations and General Academic Rules* regarding policies of the University and then refer to this bulletin for details concerning specific curricula and course offerings.

The rules and regulations published in this bulletin were in effect at the beginning of the 1976-1977 academic year and are subject to change through established procedures of the College of Pure and Applied Sciences. Changes in academic rules and regulations are effective at the beginning of the academic year following their adoption. Listings of course offerings are subject to change by concerned departments and University administrators in the event that unforseen faculty changes have taken place or insufficient numbers of students have subscribed to course offerings. The official schedule of course offerings for each semester is provided in the *Schedule of Classes,* which is published biannually by the Office of the Registrar.

The University of Lowell is an Equal Opportunity, Affirmative-Action University and does not discriminate in admissions or employment on the basis of sex in compliance with Title IX. Any inquiries concerning Title IX should be directed to the Title IX Coordinator or the Director of the Office of Civil Rights.

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COLLEGE OF PURE AND APPLIED SCIENCES

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TABLE OF CONTENTS

Academic Policies

Undergraduate Education in the Pure and Applied Sciences 2
Objectives of the College of Pure and Applied Sciences 2
Baccalaureate Degree Programs 3
General College Requirements 4-8
    Admission Requirements 4
    Attendance Requirements. 5
    Language Proficiency Requirement 5
    Declaration of Major 5
    Change of Major. 6
    Academic Advisement. 6
    Transfer Policies 6
    Repetition of Transfer Courses at the University 7
    Intercollegiate Transfer within the University 7
    Curriculum Requirements for Graduating Classes of 1977 and 1978 7
    Departmental Scholarships and Awards 8
Major Programs 9-46
    Biological Sciences. 9
    Chemistry 14
    Environmental Science 24
    Mathematics 31
    Meteorology 34
    Physics 38
    Radiological Health Physics 44
Minor Areas of Study 47-48

Course Descriptions

Course Prefixes 49
Course Numbers 49
Semester, Class, and Credit Designations 50
Course Restrictions 50
Instructor Designations 50
Department Course Offerings 51-102
    Biological Sciences. 51
    Chemistry 60
    Earth Sciences 70
    Mathematics 76
    Physics and Applied Physics 88
    Radiological Sciences. 100

College Organization and Governance 104

Faculty of the College 106

COLLEGE OF PURE AND APPLIED SCIENCES

ACADEMIC POLICIES

UNDERGRADUATE EDUCATION IN THE PURE AND APPLIED SCIENCES

Motivation for the pursuit of scientific and mathematical inquiry stems from two basic human characteristics. One is the quest for knowledge for its own sake in order to understand the workings of our universe, and the other is the desire to enlist the investigative techniques of science and mathematics in the service of humanity in order to improve the quality of life. These two aspects of science, one of which allows us to properly define the energies and matter of our reality and the other of which is applied to the task of freeing our lives from disease and deprivation, are integrated and harmonious activities—albeit from time to time the relative emphasis placed by society on each activity may change. Until the industrial revolution, the cultural side of science was in the ascendence. Since this time, a greater society awareness has been placed on the practical application of the scientific discovery process; and during the past century science has so enriched our lives that it is difficult to conceive of a truly educated person who has not had exposure to some of the concepts and methodologies of science.

Undergraduate programs in the pure and applied sciences serve the pre-professional needs of students who desire to enter such professions as medicine and provide excellent preparation for graduate studies in the several pure and applied sciences as well as for science oriented careers in business, government, and industry. Regardless of the student's career goals, however, the program of study which an individual may elect should have universal perspective and significance as well as particular depth and comprehension. It should provide experiences for developing competency in using the modes of thought characteristic of the major areas of scientific knowledge as well as providing the opportunity for developing a thorough understanding of at least one scientific area. To the degree that undergraduate education in the pure and applied sciences is the basis for further graduate training, for career preparation, or for the meaningful perception, integration and understanding of life experiences, it must be both general and specific and must be determined not only by such personal considerations as individual interests, demands, and competencies but also by such impersonal factors as the spectrum of scientific knowledge and the nature of particular scientific disciplines.

OBJECTIVES OF THE COLLEGE OF PURE AND APPLIED SCIENCES

The educational objectives of the College of Pure and Applied Sciences are to contribute to the advancement of science, to provide support and service courses for non-science majors, to provide the basic understanding of scientific concepts and methodologies which is an essential ingredient of a liberal education, and to prepare students for entry into the various science-related professions.

The curricula of the College seek to increase the capacities of students who major in the pure and applied sciences for understanding themselves and the world in which they live, especially as these capacities relate to the modes of thought which are characteristic of the major areas of scientific knowledge. To accomplish this objective, the several curricula are organized to foster fundamental communication skills in language and mathematics, to promote appreciation and comprehension of man's cultural, social, physical, and biological environment through exposure to the major areas of human knowledge, to develop a thorough understanding of the scientific method upon which all scientific endeavor is based, and to provide the special and technical knowledge which accures from a penetrating study of a particular discipline in the pure and applied sciences.

BACCALAUREATE DEGREE PROGRAMS

The College of Pure and Applied Sciences offers undergraduate programs leading to the Bachelor of Arts degree in chemistry and environmental sciences and to the Bachelor of Science degree in biological sciences, chemistry, environmental sciences, mathematics, meteorology, physics, and radiological sciences. For information concerning masters programs in biological sciences, chemistry, mathematics, physics and applied physics and doctoral programs in chemistry and physics and applied physics, see the *Graduate School Catalogue.*

Basic requirements for baccalaureate degrees in the College of Pure and Applied Sciences conform to the general requirements of the University and are as follows:

Bachelor of Arts Degree

Curricula leading to the Bachelor of Arts degree are designed to provide a broad, comprehensive education with many options for developing major and minor programs. These options are specified by each of the colleges offering Bachelor of Arts degree programs and are sufficiently flexible to satisfy the individual needs of students while also providing sufficient preparation in the major field for subsequent specialization at the graduate level.

The requirements for majors are set by each department but must specify a minimum of 30 semester credits. Although students may not be required to take more than 45 semester credits in the major field, they may elect to take additional courses in the major field beyond the specified required maximum. At least 15 credits in the major field must be taken at the upper-division course level. Bachelor of Arts degree programs require a minimum of 75 semester credits outside the major field, except as specified by the following provisions concerning second majors.

Students may elect a second major when policies of the college in which they are matriculating for the Bachelor of Arts degree permit, but they may not count more than 63 credits in the two majors combined toward the minimum degree requirement of 120 credits. Students who present more than 63 credits in the two majors combined may not present less than 57 semester credits outside the two major fields in satisfying the minimum degree requirement of 120 credits. Accordingly, students who present more than 63 credits in the two majors combined must present a number of credits beyond the minimum degree requirement of 120 credits which is equal to the number of credits by which they exceed the combined major credit maximum.

All Bachelor of Arts programs require, as a minimum, 60 credits and 15 courses in science and mathematics offerings of the College of Pure and Applied Sciences; at least three courses are required in mathematics and four courses are required in science which are exclusive of the student's major program. In order to designate courses from other colleges of the University as science courses, students must petition the Undergraduate Curriculum Committee of the College of Pure and Applied Sciences. Bachelor of Arts programs of the College of Pure and Applied Sciences also require, as a minimum, 50 credits and 15 courses from the offerings of the College of Liberal Arts, the College of Music, and the economics offerings of the College of Management Science.

Bachelor of Science Degree

The Bachelor of Science degree is designed to provide students with a specialized education in one or more of the basic sciences. Specialized Bachelor of Science curricula which are offered in areas of the pure and applied sciences and mathematics provide opportunities for major and minor program options but afford greater opportunities for major specialization than are permitted in comparable Bachelor of Arts curricula.

The requirements for majors are set by University departments or interdisciplinary committees but must specify a minimum of 30 semester credits. Although students may not be required to take more than 60 semester credits in the major field, they may elect to take additional courses in the major field beyond the specified required maximum. At least 15 credits in the major field must be taken at the upper-division course level.

All Bachelor of Science programs require, as a minimum, 74 credits and 20 courses from the offerings of the College of Pure and Applied Sciences. At least three courses are required in mathematics beyond college algebra and must include two calculus courses and one additional mathematics elective. Four courses with laboratory are required in physics and/or chemistry and two courses are recommended in collateral sciences outside the major field.

GENERAL COLLEGE REQUIREMENTS

In order to qualify for a baccalaureate degree offered by the College of Pure and Applied Sciences, undergraduates must comply with the University Core Requirements, must conform to the rules of the College of Pure and Applied Sciences which govern degree and major studies for such degrees, and must earn 2.00 averages in their major fields by the end of their senior year.

Admission Requirements

For admission to courses of study in the College of Pure and Applied Sciences, high school applicants must comply with the requirements for secondary school preparation which are described in the publication *Admission Regulations & General Academic Rules.* Transfer students to the College may expect recognition of previously completed course work in the sciences and mathematics if these courses are equivalent to those specified by the science and mathematics curricula of the College. Prerequisites for courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to the minimum requirements for a baccalaureate degree in mathematics or the sciences.

Attendance Requirements

The College values regularity of attendance in classroom and laboratory sessions as a means of achieving collegiate success. Each instructor is required to state his or her attendance regulations in writing at the beginning of each course. Students who have exceeded the number of permitted absences may be failed by the instructor unless they have withdrawn from the course before the established University deadline.

Language Proficiency Requirement

Although the College of Pure and Applied Sciences does not require language proficiency, each department has the prerogative of specifying a level of language proficiency as a collateral requirement for major studies. Students matriculating for the Bachelor of Science degree who major in chemistry or physics (pure physics option only) must pass one year of a foreign language. Students majoring in science areas or mathematics who anticipate further studies at the graduate level are strongly advised to develop an intermediate reading proficiency in French or German. Students who desire to present official evidence of language proficiency for purposes of employment or application to graduate schools may satisfy the expectations of the Department of Languages, College of Liberal Arts, for intermediate language proficiency through any one of the options cited below:

a. a score of "550" or above on the College Entrance Examination Board Achievement Test;

b. a score of "5", "4", or "3" on a College Entrance Examination Board Advanced Placement Examination;

c. a satisfactory score in a proficiency test prepared and administered by the Department of Languages of the University of Lowell (preferably during the student's freshman year);

d. passing two semester courses on the intermediate, second-year college level in a language previously studied in the secondary school and offered by the University of Lowell; or

e. passing a minimum of 12 semester credits in one language, the study of which is initiated at the Universtiy of Lowell.

Declaration of Major

Students who are admitted to the College of Pure and Applied Sciences are advised to declare their major fields during the freshman year and are required to make such declaration at the end of the sophomore year. Students who are interested in technological areas or in the sciences and mathematics but are unsure of their choice of specific major may be admitted to the College as "undeclared" students. However, an early decision by students will greatly facilitate the selection of appropriate prerequisite courses for major studies and accordinly will reduce the possibilities of time-consuming errors in judgment. Students transferring with 60 or more credits are required to make a declaration of major field upon acceptance by the College. A declaration of major field requires that the student file an official notification with the Office of the Registrar.

Change of Major

Once students have made a declaration of major field, they may not change their degree program without specific authorization from the chairperson of the new major to be declared and, in the event of an intercollegiate transfer, from the dean of the college to which they transfer. Additional course work beyond the minimum degree requirements and extension of the normal four-year period of study may be expected for students who change their majors later than the first semester of their junior year. The intercollegiate transfer policy of the University should be consulted by those who have begun their studies in the Unviersity in a college other than the College of Pure and Applied Sciences or who wish to transfer from the College of Pure and Applied Sciences to another college of the University. All changes of major require the filing of an official notification with the Office of the Registrar.

Academic Advisement

An academic advisor will be assigned to all incoming freshman and transfer students. Prior to each registration period, students should meet with their advisors to discuss their selection of academic programs. Students who fail to avail themselves of this opportunity and who register for incorrrect courses may find it necessary to extend their period of academic study. All seniors should consult with their advisors prior to the established University deadline for filing programs of study with the Office of the Dean, College of Pure and Applied Sciences. The program of study summarizes a senior's status with respect to requirements for courses and grade-point averages and insures that all stated graduation requirements have been satisfied prior to the formal approval of degree candidates by the Faculty.

Transfer Policies

Course credits for transferred work are evaluated by the Office of Admissions at the time of student transfer and in accordance with general policies of the University. Since the nature of professional and specialized programs preclude the application of non-equivalent transfer courses to specific curriculum requirements, the records of transfer students are also evaluated by major departments at the time a student is accepted for matriculation by one of the colleges of the University. All transferred courses which have been accepted by the University are listed on the student's permanent record card, and those courses which are not applicable to specific curriculum requirements are credited, whenever possible, as "unrestricted elective courses."

Since some curricula do not provide for such "unrestricted elective courses," or the number of transferred courses may exceed the number of "unrestricted elective courses" which are permitted within the specifications for a minimum degree requirements, transferred courses which are not applicable to the specific requirements of a curriculum are not counted in the determination of the number of "course hours completed" until the semester of graduation. (Cf. "Academic Standing," *Admission Regulations and General Academic Rules,* for an explanation of "course hours completed.") This procedure prevents the early imposition of a grade point requirement for retention which is in excess of that specified for the number of credits completed and applicable to the student's particular curriculum. For instance, a student who transfers 60 credits is required to achieve a grade-point average of 1.80 for the first 15 credits attempted at the University. In the event that 30 of these credits are not applicable to his or her professional or academic curriculum, he or she will be charged with the completion of 30 course credits and will be required to achieve a grade-point average of 1.60 for the first 15 credits attempted at the University.

The applicability of grades received in transferred courses for the determination of the grade-point average of the student's major at the University of Lowell is determined by policies of each of the colleges. The policy of the College of Pure and Applied Sciences is *not* to count such grades for the purpose of determining the student's major grade-point average.

Repetition of Transfer Courses at the University

A student who has been granted transfer credit, and on this basis has been assigned to advanced courses for which the transferred course is a prerequisite, may be advised to repeat such transferred work at the University or to take a more elementary course than that which has been transferred when the competence of the student has been demonstrably inadequate. Permission to repeat a transferred course is granted by filing an academic petition form through the office of the College dean. Since credit may not be granted more than once for the completion of any course, a condition for filing such a petition is the simultaneous filing of a request to revoke recognition of the previously transferred course.

Intercollegiate Transfer within the University

Procedures for making an intercollegiate transfer within the University are described under the heading "Change of Enrollment Status" in the bulletin entitled *Admission Regulations and General Academic Rules.* Students who have been approved for transfer to this College from other colleges of the University may apply for deletion of unrelated courses from their cumulative grade-point averages in accordance with established University policy. Such deleted courses are not removed from the permanent record card and may be recomputed in the cumulative grade-point average in the event of a subsequent intercollegiate transfer.

Curriculum Requirements for the Graduating Classes of 1977 and 1978

Curriculum requirements as specified by the relevant catalogues of Lowell State College and Lowell Technological Institute continue to apply to students of the College of Pure and Applied Sciences who are members of the graduating classes of 1977 and 1978. Students completing the major requirements previously specified by the *Bulletin of Undergraduate Studies,* Lowell State College, 1974-1976, are also subject to the general degree requirements and the Uniform College Requirements which are specified in this publication. Students completing the major requirements previously specified by the *Bulletin of the Lowell Technological Institute,* 1974-1975, are also subject to the general degree requirements which are specified in this publication. Students who transfer to the College of Pure and Applied Sciences from other institutions or from other colleges of the University and who are granted advanced standing in the classes of 1977 and 1978 are subject to all requirements as stated in the catalogues detailing the major program which they elect. For instance, a student who elects to complete the biology major previously in effect at Lowell State College must complete all degree requirements as specified by the catalogue of Lowell State College. Similarly, a student who elects to complete the biological sciences major previously in effect at Lowell Technological Institute must complete all degree requirements as specified by the catalogue of Lowell Technological Institute. A student may not elect to complete the major requirements as specified in one catalogue and the degree requirements as specified in the other. For specific information concerning these requirements, students should consult the *Bulletin of Undergraduate Studies,* Lowell State College, 1974-1976, the *Bulletin of the Lowell Technological Institute,* 1974-1975, or should confer with their faculty advisors and major department chairpersons.

Departmental Scholarships and Awards

American Chemical Society Student Affiliate Chapter Award. An award is presented annually by the ACS Student Affiliate Chapter to the outstanding senior majoring in chemistry or chemical engineering based upon academic performance and demonstration of research capability.

Chemistry Award: An award is given to the freshman student in chemistry who shows the greatest achievement in chemistry.

Dean's Key: This award is sponsored by the College of Pure and Applied Sciences and is given to a graduating senior who has displayed academic excellence in course work and in other scholastic activities.

Departmental Awards: An award by the Chemical Rubber Company is presented annually to the outstanding freshman in each of the following programs: chemistry, mathematics, and physics.

Roland E. Derby, Sr. Memorial Scholarship: This scholarship is awarded in alternate years to a sophomore who is a chemistry or chemical engineering major and is granted on the basis of scholarship and financial need. The stipend is $500 per year and is renewable for recipients in good academic standing.

Russell Weeks Hook Scholarship: This scholarship is awarded each year to two chemistry majors in the sophomore, junior and senior classes and is granted on the basis of scholarship and financial need. The stipend is $225 per year and is renewable for recipients in good academic standing.

Dr. Charles R. Mingins Award: This award is given in honor of the first chairman of the Department of Physics and is granted to the senior physics or applied physics major who has evidenced the highest scholastic achievement and research aptitude.

Louis A. Olney Book Prizes: Stipends of $40, $60, and $100 are awarded each spring respectively to a sophomore, junior and senior chemistry major. Awards are based solely on scholastic achievement.

William C. Smith Trust Fund: This fund provides $500 per year for scholarship assistance for chemistry majors.

MAJOR PROGRAMS

Biological Sciences

Curricula in the biological sciences are designed to provide appropriate sequences of science and liberal arts courses which will develop those scientific attitudes and habits of mind which are fundamental to successful careers in biology and cognate fields. Two program options (Track I and Track II) are offered under the requirements for the Bachelor of Science degree and provide students with opportunities to tailor their undergraduate education in accordance with their personal interests and career goals and the specific requirements of graduate and professional schools. Track selection is made by the student, in consultation with a faculty advisor, at the end of a common freshman year. Students demonstrating high scholastic ability in either track may conduct investigative studies throughout the senior year and complete an original research project. A pre-medical advisor is available for students specifically interested in dentistry and medicine.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified physics and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II Major Field Requirements 74-79

A Biological Sciences 39-41

81-111:	Principles of Biology I	3
81-113:	Principles of Biology I Laboratory	1
81-112:	Principles of Biology II	3
81-114:	Principles of Biology II Laboratory	1
81-201:	General Microbiology	3
81-203:	General Microbiology Laboratory	1
81-252:	Mammalian Physiology and	3
81-254:	Mammalian Physiology Laboratory or	1
81-324:	General and Comparative Physiology and	(3)
81-326:	General and Comparative Physiology Laboratory	(1)
81-335:	Principles of Genetics and	3
81-337:	Principles of Genetics Laboratory or	1
81-371:	Introduction to Molecular Genetics and	(3)
81-373:	Introduction to Molecular Genetics Laboratory	(1)
81-306:	Biochemistry	3
81-451:	Senior Seminar in Advanced Topics I	1
81-452:	Senior Seminar in Advanced Topics II	1
	Four electives with an "81" prefix	14-16

B Supporting Sciences and Mathematics 35-38

84-121:	Chemistry	3
84-123:	Chemistry Laboratory	1
84-126:	Chemistry	3
84-124:	Chemistry Laboratory	1
84-221:	Organic Chemistry IA	3
84-227:	Organic Chemistry Laboratory IA or	1
84-229:	Organic Chemistry Laboratory IA	(1)
84-222:	Organic Chemistry IIA	3
84-228:	Organic Chemistry Laboratory IIA or	1
84-230:	Organic Chemistry Laboratory IIA	(1)
92-131:	Calculus I-B or	4
92-133:	Calculus I-A	(4)
92-132:	Calculus II-B or	4
92-134:	Calculus II-A	(4)
92-385:	Biostatistics	3
95-141:	Introductory Physics and	3
95-142:	Concepts of Physics I and	3
95-243:	Concepts of Physics II and	2
96-141:	Fundamentals of Experimental Physics I and	1
96-144:	Fundamentals of Experimental Physics II and	1
96-245:	Fundamentals of Experimental Physics III or	1
95-201:	Principles of Physics I and	(3)
95-202:	Principles of Physics II and	(3)
96-201:	Principles of Experimental Physics I and	(1)
96-202:	Principles of Experimental Physics II	(1)

III Program Options 20-25

A Track I

This program provides an opportunity to elect a more flexible program than is possible in Track II. All courses above and beyond the University Core Requirements and the Major Field Requirements are selected by students in accordance with their needs, talents, and interests and in consultation with their faculty advisors. Minor areas of study* may be selected in the fine arts, sciences, humanities, behavioral sciences, and social sciences.

* A minimum of 6 credits at the "300"-"400" level is required for all minors.

B Track II

This option is a directed program which affords the student an opportunity to develop an in-depth proficiency in the experimental and quantitative approaches to problem solving in the field of biology. Appreciation of the importance of a breadth of understanding of related scientific disciplines is stressed. This option should provide the student with a competitive advantage in areas of science which deal with modern quantitative concepts.

IV Minimum Credit Requirements 122

Prerequisites for courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to requirements for degrees in the College of Pure and Applied Sciences. All Bachelor of Science programs require, as a minimum, 74 credits and 20 courses from the offerings of the College of Pure and Applied Sciences.

SAMPLE COURSE OF STUDY FOR BIOLOGICAL SCIENCES
(Bachelor of Science Degree—Track I)

Freshman Year

Fall Semester

* 81-111	Principles of Biology I	3
* 81-113	Principles of Biology I Laboratory	1
84-121	Chemistry	3
84-123	Chemistry Laboratory	1
+ 92-131	Calculus B-I	4
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

* 81-112	Principles of Biology II	3
* 81-114	Principles of Biology II Laboratory	1
84-126	Chemistry	3
84-124	Chemistry Laboratory	1
+ 92-132	Calculus B-II	4
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

81-201	General Microbiology	3
81-203	General Microbiology Laboratory	1
84-221	Organic Chemistry I-A	3
+ 84-229	Organic Chemistry Laboratory	1
95-201	Principles of Physics I	3
96-201	Principles of Experimental Physics I	1
	Elective	3-4
		15-16

Spring Semester

+ 81-252	Mammalian Physiology	3
+ 81-254	Mammalian Physiology Laboratory	3
84-222	Organic Chemistry II-A	3
+ 84-230	Organic Chemistry II-A Laboratory	1
95-202	Principles of Physics II	3
96-202	Principles of Experimental Physics II	1
92-385	Biostatistics	3
		15

Junior Year

Fall Semester

+ 81-335	Principles of Genetics	3
+ 81-337	Principles of Genetics Laboratory	1
	Electives	9-12
		13-16

Spring Semester

81-306	Biochemistry	3
	Electives	12-15
		15-18

Senior Year

Fall Semester

81-451	Senior Seminar in Advanced Topics	1
	Electives	15
		16

Spring Semester

81-452	Senior Seminar in Advanced Topics	1
	Electives	14
		15

* 81-111,113 are not prerequisite to 81-112, 114 and may be taken fall or spring semesters.

+ Cf. Summary of Degree Requirements for listings of approved alternative courses.

# Elective may be substituted.

SAMPLE COURSE OF STUDY FOR BIOLOGICAL SCIENCES
(Bachelor of Science Degree—TrackII)

Freshman Year

Fall Semester

* 81-111	Principles of Biology I	3
* 81-113	Principles of Biology I Laboratory	1
84-121	Chemistry	3
84-123	Chemistry Laboratory	1
+ 92-131	Calculus B-I	4
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

* 81-112	Principles of Biology II	3
* 81-114	Principles of Biology II Laboratory	1
84-126	Chemistry	3
84-124	Chemistry Laboratory	1
+ 92-132	Calculus B-II	4
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

81-201	General Microbiology	3
81-203	General Microbiology Laboratory	1
84-221	Organic Chemistry I-A	3
84-229	Organic Chemistry Laboratory	1
+ 95-141	Introductory Physics I	3
+ 96-141	Fundamentals of Experimental Physics I	1
+ 92-231	Calculus B-III	3
		15

Spring Semester

+ 81-252	Mammalian Physiology	3
+ 81-254	Mammalian Physiology Laboratory	1
84-222	Organic Chemistry II-A	3
84-230	Organic Chemistry II-A Laboratory	1
+ 95-142	Concepts of Physics II	3
+ 96-144	Fundamentals of Experimental Physics II	1
92-385	Biostatistics	3
		15

Junior Year

Fall Semester

+ 81-335	Principles of Genetics	3
+ 81-337	Principles of Genetics Laboratory	1
84-335	Principles of Physical Chemistry I	3
84-337	Principles of Physical Chemistry Laboratory	1
# 95-243	Concepts of Physics II	2
# 96-245	Fundamentals of Experimental Physics III	1
	Elective	3-4
		14-15

Spring Semester

81-306	Biochemistry	3
84-336	Principles of Physical Chemistry II	3
84-338	Principles of Physical Chemistry Laboratory	1
	Electives	9
		16

Senior Year

Fall Semester

81-451	Senior Seminar in Advanced Topics	1
81-308	Biochemistry Laboratory	1
98-441	Radioisotope Techniques	3
98-443	Radioisotope Techniques Laboratory	1
	Electives	10-12
		16-18

Spring Semester

81-452	Senior Seminar in Advanced Topics	1
	Electives	13-16
		14-17

* 81-111,113 are not prerequisite to 81-112, 114 and may be taken fall or spring semesters.

+ Cf. Summary of Degree Requirements for listings of approved alternative courses.

# Elective may be substituted.

Chemistry

Chemistry is both a basic and an applied science and, as such, is fundamental not only to an understanding of the structure, properties, and reactions of matter, but also to comprehension of the very nature of twentieth-century civilization. Career opportunities in chemistry are as many and as varied as are the applications of chemistry to contemporary life and include, by way of example, applied and basic research, product analysis, manufacturing, and marketing. Completion of the chemistry curricula also provides preparation for all areas of the chemical profession as well as for graduate study in chemistry, dentistry, medicine, and teaching.

Both the Bachelor of Arts and the Bachelor of Science degree programs have been approved by the Committee on Professional Training of the American Chemical Society, and program options and course offerings are designed to meet the latest recommended standards. However, program options permit students to graduate as chemistry majors without meeting all of the requirements of the American Chemical Society. In such cases, a degree is not certified by the Society. Major programs for the Bachelor of Arts and Bachelor of Science degrees include required courses which supply a thorough grounding in basic chemistry principles and techniques and provide flexible requirement options in areas of analytical chemistry, biochemistry, environmental chemistry, inorganic chemistry, organic chemistry, physical chemistry, radiochemistry, and polymer chemistry. Chemistry programs also permit the incorporation of specialized laboratory or research courses which provide up-to-date knowledge concerning the utilization of such sophisticated instrumentation as atomic absorption spectroscopy, electron microscopy, gas liquid chromatography, nuclear magnetic resonance spectroscopy, and x-ray spectroscopy. In addition to supporting courses in physics and mathematics, the two chemistry curricula also include courses in the humanities and social sciences and permit limited elective programs in such fields as chemical engineering, business administration, technical writing and illustrating, and environmental science.

Bachelor of Arts Degree

The Bachelor of Arts curriculum offers the student who is interested in such fields as chemical journalism or literature, illustrative arts (e.g., chemical graphics and illustrations), languages (technical translating), social sciences and the humanities with the opportunity to elect a major in chemistry while also pursuing options in areas of the humanities and social sciences. The Bachelor of Arts curriculum is also an appropriate program for students who are interested in preparing for teaching at the secondary school level and wish to pursue a graduate program in education. Although the curriculum of the Bachelor of Science degree is generally elected by students who are interested in professional careers in chemistry fields, the curriculum of the Bachelor of Arts degree is an equally appropriate choice for such students, especially when it is completed in accordance with requirements of the American Chemical Society.

For American Chemical Society Certification, 500 laboratory hours in chemistry and the equivalent of 400 hours of traditional classroom work in chemistry are required (44-46 credits).* In addition to the chemistry core noted below, the ACS requires Advanced Inorganic Chemistry (84-334) or Biochemistry (84-422) plus two semesters of advanced work presented at a level that utilizes fully the concepts and techniques developed in the core curriculum. Many patterns of advanced work are possible and appropriate, depending on individual interests and objectives. Advanced work in chemistry may include further courses in traditional areas of chemistry as well as polymer chemistry, biochemistry, and independent study and research. Alternatively, advanced work, approved by the Undergraduate Program Committee of the Chemistry Department, may be pursued outside of the department in, for example, physics, biology, or engineering. Not more than 45 credits in chemistry may be counted toward the minimum requirements of 122 credits for the Bachelor of Arts degree.

*The required chemistry core of 36 credits provides 378 hours of lecture and 434 hours of laboratory.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified physics and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II Major Field Requirements # 61-64

A Chemistry* 36

84-121:	Chemistry	3
84-123:	Chemistry Laboratory	1
84-126:	Chemistry	3
84-124:	Chemistry Laboratory or	1
84-135:	Honors Chemistry	(3)
84-137:	Honors Chemistry Laboratory	(1)
84-136:	Honors Chemistry	(3)
84-138:	Honors Chemistry Laboratory	(1)
84-221:	Orangic Chemistry IA	3
84-227:	Organic Chemistry Laboratory IA	1
84-222:	Organic Chemistry IIA	3
84-228:	Organic Chemistry Laboratory IIA	1
84-207:	Inorganic Chemistry & Qualitative Analysis	4
84-313:	Analytical Chemistry I	3
84-315:	Analytical Chemistry I Laboratory	1
84-314:	Analytical Chemistry II	3
84-316:	Analytical Chemistry II Laboratory	1
84-332:	Physical Chemistry	4
84-333:	Physical Chemistry	4

* ACS accreditation requires additional courses beyond the chemistry core. Cf. ACS requirements above. Not more than 45 credits in chemistry may be credited to the minimum BA requirement of 122 credits.

B Supporting Sciences and Mathematics 25-28

95-201:	Principles of Physics I	3
96-201:	Principles of Experimental Physics I	1
95-202	Principles of Physics II	3
96-202	Principles of Experimental Physics II	1
92-131:	Calculus I-B and	4
92-132:	Calculus II-B and	4
92-231:	Calculus III-B or	4
92-133:	Calculus I-A	(4)
92-134:	Calculus II-A	(4)
92-233	Calculus III-A	(3)
	Science electives to achieve a total of 60 credits in science and mathematics, inlcuding two additional science courses exclusive of mathematics and chemistry	6-8

III Program Options # 29

A minimum of 29 credits (in addition to Area I and Area II) must be taken from course offerings of the College of Liberal Arts, the College of Music, and the economics offerings of the College of Management Science. These courses are selected by students in accordance with their needs, interests, and talents, and in consulation with faculty advisors. Minor areas of study* may be selected in the College of Liberal Arts. A minor in economics* may also be selected in the College of Management Science.

*A minimum of 6 credits at the "300"-"400" level is required for all minor areas.

IV	Unrestricted Elective Courses #	6-9
V	Minimum Credit Requirement	122

# Courses which are prerequisites for physics, chemistry, and mathematics courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to requirements for a baccalaureate degree in chemistry.

SAMPLE COURSE OF STUDY FOR CHEMISTRY
(Bachelor of Arts Degree)

Freshman Year

Fall Semester			Spring Semester		
* 84-121	Chemistry	3	* 84-126	Chemistry	3
* 84-123	Chemistry Laboratory	1	* 84-124	Chemistry Laboratory	1
95-201	Principles of Physics I	3	95-202	Principles of Physics II	3
96-201	Principles of Experimental Physics	1	96-202	Principles of Experimental Physics	1
* 92-131	Calculus B-I	4	* 92-132	Calculus B-II	4
42-101	College Writing	3	42-102	College Writing & Literature	3
39	Physical Education	1	39	Physical Education	1
		16			16

Sophomore Year

Fall Semester			Spring Semester		
84-221	Organic Chemistry IA	3	84-222	Organic Chemistry IIA	3
84-227	Organic Chemistry Laboratory	1	84-228	Organic Chemistry Laboratory	1
* 92-231	Calculus B-III	4	84-332	Physical Chemistry	4
84-207	Inorganic Chemistry	4		Electives +	6-9
	Electives +	3-6			14-17
		15-18			

Junior Year

Fall Semester			Spring Semester		
84-313	Analytical Chemistry I	3	84-314	Analytical Chemistry II	3
84-315	Analytical Chemistry Laboratory	1	84-316	Analytical Chemistry Laboratory	1
84-333	Physical Chemistry	4		Electives + #	12-14
	Electives + #	8-9			16-18
		16-17			

Senior Year

Fall Semester			Spring Semester		
	Electives + #	14-16		Electives + #	14-16

* Cf. Summary of Degree Requirements for listings of approved alternative courses.

+ University Core Requirements, Supporting Sciences & Mathematics, liberal arts, music, or economics courses, or general electives.

# For American Chemical Society approved programs of study, 84-334 or 84-422 is required.
The following are recommended chemistry electives with laboratory hours:
84-321 (1-6) 3; 84-342 (1-6) 3; 84-405 (0-4) 1; 84-406 (0-4) 1;
84-407 (0-9) 3; 84-408 (0-9) 3; 84-481 (2-3) 3; 84-482 (2-3) 3.
Cf. ACS program requirements under general statement concerning the chemistry major.

Bachelor of Science Degree

The Bachelor of Science curriculum is directed to students who are interested in becoming professional chemists. Although the curriculum specifies a basic core of courses which are directed to basic principles and techniques, it is a flexible program of requirements which allows each student to select advanced courses according to his or her interests and goals and to pursue studies which combine proficiency in chemistry with training in such fields as business administration, biological sciences, mathematics, chemical engineering, electrochemistry, radiochemistry, materials science, chemical energy, and polymer chemistry. Courses in physics, mathematics, languages, social science, and literature serve to support the chemistry courses and to prepare the student to interact effectively in both social and professional settings.

For American Chemical Society Certification, 500 laboratory hours in chemistry and the equivalent of 400 hours of traditional classroom work in chemistry are required.* In addition to the chemistry core noted below, the ACS requires Advanced Inorganic Chemistry (84-334) or Biochemistry (84-422), plus two semesters of advanced work presented at a level that utilizes fully the concepts and techniques developed in the core curriculum. Many patterns of advanced work are possible and appropriate, depending on individual interests and objectives. Advanced work in chemistry may include further courses in traditional areas of chemistry as well as polymer chemistry, biochemistry, and independent study and research. Alternatively, advanced work, approved by the Undergraduate Program Committee of the Chemistry Department, may be pursued outside of the department in, for example, physics, biology, or engineering.

*The required chemistry core of 36 credits provides 378 hours of lecture and 434 hours of laboratory.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*#
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified physics and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

# Six credits of a foreign language are required.

II	Major Field Requirements		64-71
	A	Chemistry*	36
	84-121:	Chemistry	3
	84-123:	Chemistry Laboratory	1
	84-126:	Chemistry	3
	84-124:	Chemistry Laboratory or	1
	84-135:	Honors Chemistry	(3)
	84-137:	Honors Chemistry Laboratory	(1)
	84-136:	Honors Chemistry	(3)
	84-138:	Honors Chemistry Laboratory	(1)
	84-221:	Orangic Chemistry IA	3
	84-227:	Organic Chemistry LaboratoryIA	1
	84-222:	Organic Chemistry IIA	3
	84-228:	Organic Chemistry Laboratory IIA	1
	84-207:	Inorganic Chemistry & Qualitative Analysis	4
	84-313:	Analytical Chemistry I	3
	84-315:	Analytical Chemistry Laboratory I	1
	84-314:	Analytical Chemistry II	3
	84-316:	Analytical Chemistry Laboratory II	1
	84-332:	Physical Chemistry	4
	84-333:	Physical Chemistry	4

* The minimum chemistry requirement for ACS certification is 44 credits. Cf. ACS program requirements under the general statement concerning the chemistry major.

B Physics 12-17

- 95-141: Introductory Physics and 3
- 96-147: Fundamentals of Experimental Physics I (Honors) or 1
  - 95-147: Honors Physics I and (4)
  - 96-147: Fundamentals of Experimental Physics I (Honors) (1)
- 95-144: Fundamentals of Physics I and 3
- * 96-144: Fundamentals of Experimental Physics II or 1
  - 95-148: Honors Physics II and (4)
  - 96-148: Fundamentals of Experimental Physics (Honors) (1)
- 95-245: Fundamentals of Physics II and 3
- + 96-245: Fundamentals of Experimental Physics III or 1
  - 95-247: Honors Physics III (4)
  - 96-293: Experimental Physics I (3)

* 96-148 may be substituted for 96-144.
+ 96-293 may be substituted for 96-245.

C Mathematics 16-18

- 92-131: Calculus I-B 4
- 92-132: Calculus II-B 4
- 92-231: Calculus III-B 4
- 92-232: Calculus IV-B or 4
  - 92-131: Calculus I-B (4)
  - 92-132: Calculus II-B (4)
  - 92-131: Calculus III-B (4)
  - * 92-383: Introduction to Statistics or (3)
    - 92-133: Calculus I-A (4)
    - 92-134: Calculus II-A (4)
    - 92-233: Calculus III-A (3)
    - 92-234: Calculus IV-A or (3)
      - 92-133: Calculus I-A (4)
      - 92-134: Calculus II-A (4)
      - 92-233: Calculus III-A (3)
      - * 92-383: Introduction to Statistics (3)
- 92-361: Digital Computer Programming 2

* 92-383 is strongly recommended.

III Allied Courses 18-24

The required chemistry minimums permit students to elect limited programs outside the Department of Chemistry for the purpose of developing specific interests. In consultation with their advisors, students may choose a minor of 18-24 credits or may wish to consider the following groups of electives as preparation for various fields allied with chemistry. A minimum of 6 credits at the "300"-"400" level is required for all minors.

Chemical Engineering Electives

10-203:	Introduction to Chemical Engineering	3
10-204:	Chemical Engineering Calculus	3
10-206:	Fluid Mechanics	3
10-305:	Heat Transfer	3
10-306:	Transport Phenomena	3
10-409:	Economic and Process Analysis	3
10-310:	Separation Processes	3

The chemical engineering sequence prepares the student to enter a master's program in chemical engineering with minimum deficiences in instrumentation, controls, and reaction kinetics.

Business Administration Electives

66-200:	The Business System	3
60-201:	Accounting Principles I	3
60-202:	Accounting Principles II	3
64-201:	Economics I	3
64-202:	Economics II	3
* 64-211:	Statistics I	3
* 64-212:	Statistics II	3

Materials Science Electives

10-308:	Engineering Materials	3
22-395:	Materials Science	3
26-201:	Polymeric Materials I	3
26-202:	Polymeric Materials II	3
84-403:	Introductory Polymer Science I	3
84-404:	Introductory Polymer Science II	3
84-405:	Polymer Laboratory I	1
84-406:	Polymer Laboratory II	1

Electrochemistry Electives

16-201:	Introductory Circuit Theory I	4
16-207:	Electrical Engineering Laboratory	2
16-202:	Introductory Circuit Theory II	4
16-208:	Electrical Engineering Laboratory	2

Chemical Energy Electives

10-431:	Coal Technology	3
10-434:	Petrochemicals	3
16-471:	Energy Conversion	3
80-201:	Physics of Radiation	3
80-202:	Physics of Nuclei	3

*Students may not receive credit for both 92-383 and 64-211, 212.

IV Unrestricted Elective Courses # 4-17

# Prerequisites for physics, chemistry, and mathematics courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to requirements for a baccalaureate degree in chemistry. All Bachelor of Science programs require, as a minimum, 74 credits and 20 courses from the offerings of the College of Pure and Applied Sciences.

V Minimum Credit Requirement 122

SAMPLE COURSE OF STUDY FOR CHEMISTRY
(Bachelor of Science Degree)

Freshman Year

Fall Semester

* 84-121	Chemistry	3
* 84-123	Chemistry Laboratory	1
* 95-141	Introductory Physics	3
* 96-147	Fundamentals of Experimental Physics (Honors)	1
* 92-131	Calculus B-I	4
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

* 84-126	Chemistry	3
* 84-124	Chemistry Laboratory	1
* 95-144	Fundamentals of Physics I	3
* 96-144	Fundamentals of Experimental Physics	1
* 92-132	Calculus B-II	4
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

84-221	Organic Chemistry IA	3
84-227	Organic Chemistry Laboratory	1
* 92-231	Calculus B-III	4
* 95-245	Fundamentals of Physics	3
* 96-245	Fundamentals of Experimental Physics	1
84-207	Inorganic Chemistry	4
		16

Spring Semester

84-222	Organic Chemistry IIA	3
84-228	Organic Chemistry Laboratory	1
* 92-232	Calculus B-IV	4
92-361	Digital Computer Programming	2
84-332	Physical Chemistry	4
	Elective +	3
		17

Junior Year

Fall Semester

84-313	Analytical Chemistry I	3
84-315	Analytical Chemistry Laboratory	1
84-333	Physical Chemistry	4
	Foreign Language	3
	Electives +	6
		17

Spring Semester

84-314	Analytical Chemistry II	3
84-316	Analytical Chemistry Laboratory	1
	Foreign Language	3
	Electives + #	9
		16

Senior Year

Fall Semester

	Electives + #	15-16

Spring Semester

	Electives + #	15-16

* Cf. Summary of Degree Requirements for listings of approved alternative courses.

+ University Core Requirements,minor or allied field electives, and general electives.

# For American Chemical Society approved programs of study, 84-334 or 84-422 is required.
The following are recommended chemistry electives with laboratory hours:
84-321 (1-6) 3; 84-342 (1-6) 3; 84-405 (0-4) 1; 84-406 (0-4) 1;
84-407 (0-9) 3; 84-408 (0-9) 3; 84-481 (2-3) 3; 84-482 (2-3) 3.
For further information, see ACS requirements under the general statement concerning the chemistry major.

Environmental Science

The major in environmental sciences is a broad-based, interdisciplinary program which is designed to provide students with an understanding of the complex inter-relationships which exist at the earth's surface. The program, which is offered with options leading to the Bachelor of Arts and Bachelor of Science degrees, focuses on physical and biological systems but also recognizes the related nature of social and economic studies. A major in environmental science will prove useful for students planning to pursue graduate work in environmental studies and in education or who wish to pursue environmentally oriented careers in business, government, and industry.

Bachelor of Arts Degree

This degree program is designed for students who wish to obtain a broad-based background in the sciences and related humanities and social sciences. A number of unrestricted elective courses permit maximum flexibility in designing a program of study which will satisfy personal goals within the context of individual competencies. Students pursuing the Bachelor of Arts degree program must complete a minimum of 50 credits and 15 courses from the offerings of the College of Liberal Arts, the College of Music, or the economics offerings of the College of Management Science. The following courses are required for the Bachelor of Arts degree in environmental science.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirement. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented form the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified science and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II	Major Field Requirements		77-84
	A	Environmental Sciences	25
	87-101:	Introduction to Environmental Sciences	1
	87-102:	Foundations of Conservation	3
	87-232:	Atmospheric Science	3

87-234:	Atmospheric Science Laboratory	1
87-401:	Seminar in Environmental Science I	3
89-203:	Oceanography	3
89-205:	Oceanography Laboratory	1
89-213:	Environmental Geology	3
89-314:	Hydrogeology	3
81-315:	Principles of Ecology	2
81-317:	Principles of Ecology Laboratory	2

B Area of Focus 14-16

Environmental science majors must elect a minimum of four courses (14 or more semester credits) from one of the following three categories:

1. Biological Aspects of Environmental Science

81-201:	General Microbiology	3
81-203:	General Microbiology Laboratory	1
81-302:	Developmental Biology	2
81-304:	Experimental Morphogenesis	2
81-310:	Cell Biology	3
81-312:	Cell Biology Laboratory	1
81-331:	Quantitative Ecology	3
81-333:	Quantitative Ecology Laboratory	1
81-335:	Genetics	3
81-337:	Genetics Laboratory	1
81-422:	Plant Physiology	3
81-424:	Plant Physiology Laboratory	1
82-215:	Introduction to Marine Biology	2
82-217:	Introduction to Marine Biology Laboratory	1
82-346:	Introductory Entomology	2
82-348:	Introductory Entomology Laboratory	1
82-347:	Ornithology	2
82-349:	Ornithology Laboratory	1
82-354:	Wildlife & Environmental Management	3

2. Geological Aspects of Environmental Science

89-208:	Paleontology	3
89-210:	Paleontology Laboratory	1
89-251:	Mineralogy	3
89-253:	Mineralogy Laboratory	1
89-301:	Optical Mineralogy	3
89-303:	Optical Mineralogy Laboratory	1
89-304:	Igneous and Metamorphic Petrology	3
89-306:	Igneous and Metamorphic Petrology Laboratory	1
89-316:	Geomorphology	3
89-318:	Geomorphology Laboratory	1
89-322:	Structural Geology	3
89-324:	Structural Geology Laboratory	1
89-352:	Stratigraphy and Sedimentation	3
89-354:	Stratigraphy and Sedimentation Laboratory	1
89-452:	Geochemistry	3

3. Chemical Aspects of Environmental Science

84-207:	Inorganic Chemistry	4
84-221:	Organic Chemistry I	3
84-222:	Organic Chemistry II	3
84-227:	Organic Chemistry Laboratory I	1
84-228:	Organic Chemistry Laboratory II	1
84-313:	Analytical Chemistry I	3
84-314:	Analytical Chemistry II	3
84-315:	Analytical Chemistry Laboratory I	1
84-316:	Analytical Chemistry Laboratory II	1
84-335:	Principles of Physical Chemistry I	3
84-337:	Principles of Physical Chemistry LaboratoryI	1
84-342:	Organic Qualitative Analysis	3

C Supporting Sciences and Mathematics 38-43

1. 92-131: Calculus B-1 or 92-133: Calculus A-1 and two additional mathematics courses 10-12
2. 83-101, 103: Life Science I and Laboratory; 83-102, 104: Life Science I and Laboratory or 81-111, 113: Principles of Biology I and Laboratory and 81-112, 114: Principles of Biology II and Laboratory 8
3. 84:121, 123: Chemistry and Chemistry Laboratory plus
   84-122, 123: Chemical Principles and Laboratory or
   84-126, 124: Chemistry and Chemistry Laboratory 8
4. 95-201, 202 and 96-201, 202: Principles of Physics and Laboratory or
   95-141, 144, 245 and 96-141, 144, 245: Physics and Laboratory 8-11
5. 89-121, 123: Physical Geology and Laboratory 4

D Elective Courses 29

Students pursuing the Bachelor of Arts degree are required, at a minimum, to take 29 credits from the offerings of the College of Liberal Arts, the College of Music, or the economics offerings of the College of Management Science. These courses* are selected by students in accordance with their needs, talents, and interests and in consultation with their faculty advisors.

* Minor areas of study require a minimum of credits at the "300"-"400" level.

IV Minimum Credit Requirement 129

SAMPLE COURSE OF STUDY FOR ENVIRONMENTAL SCIENCES
(Bachelor of Arts Degree)

Freshman Year

Fall Semester

42-101	College Writing	3
84-121	Chemistry	3
84-123	Chemistry Laboratory	1
92-131	Calculus B-I	4
89-121	Physical Geology	3
89-123	Physical Geology Laboratory	1
87-101	Introduction to Environmental Science	1
39	Physical Education	1
		17

Spring Semester

42-102	College Writing & Literature	3
84-122	Chemistry	3
84-124	Chemistry Laboratory	1
87-102	Foundations of Conservation	3
92	Mathematics Elective	3-4
	Elective (Area I or II)	3
39	Physical Education	1
		17-18

Sophomore Year

Fall Semester

81-111	Principles of BiologyI	3
81-113	Principles of Biology I Laboratory	1
95-201	Principles of PhysicsI	3
96-201	Principles of Physics I Laboratory	1
89-213	Environmental Geology	3
92	Mathematics Elective	3-4
	Elective (Area I or II)	3
		17-18

Spring Semester

81-112	Principles of Biology II	3
81-114	Principles of Biology II Laboratory	1
95-202	Principles of Physics II	3
96-202	Principles of Physics II Laboratory	1
89-314	Hydrogeology	3
	Elective (Area I or II)	3
	Elective (Liberal Arts)	3
		17

Junior Year

Fall Semester

89-203	Oceanography	3
89-205	Oceanography Laboratory	1
81-315	Principles of Ecology	3
81-317	Principles of Ecology Laboratory	1
	Elective (Focus)	4
	Elective (Area I or II)	3
		15

Spring Semester

87-232	Atmospheric Science	3
87-234	Atmospheric Science Laboratory	1
	Elective (Focus)	4
	Elective (Area I or II)	3
	Elective (Liberal Arts)	4
		15

Senior Year

Fall Semester

87-401	Environmental Science Seminar	3
	Elective	3-4
	Electives (Liberal Arts)	9
		15-16

Spring Semester

	Elective (Focus)	3-4
	Electives (Liberal Arts)	12
		15-16

Bachelor of Science Degree

For those students who are interested in the field of geology, an option in this field is provided within the framework of the Bachelor of Science degree program. A major in environmental science with an option in geology will provide a basic foundation for subsequent studies in such subfields of applied geology as mineral exploration and exploitation, engineering geology, geologic hazard evaluation, and energy resource development. For the student possessing the necessary science competencies, a wide range of career opportunities is available. These opportunities range from studies of the oceans and the solid earth to the origin of the earth and other astronomical bodies. Students planning to pursue such career opportunities should recognize that training at the graduate level is required in most cases.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirement. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified science and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II	Major Field Requirements		92-96
	A	Environmental Sciences	22
	87-101:	Introduction to Environmental Sciences	1
	87-102:	Foundations of Conservation	3
	87-232:	Atmospheric Science	3
	87-234:	Atmospheric Science Laboratory	1
	87-401:	Seminar in Environmental Science I	3
	89-203:	Oceangraphy	3
	89-205:	Oceanography Laboratory	1
	89-314:	Hydrogeology	3
	81-315:	Principles of Ecology	2
	81-317:	Principles of Ecology Laboratory	2

B	Geology Option		31
	89-208:	Paleontology	3
	89-210:	Paleontology Laboratory	1
	89-251:	Mineralogy	3
	89-253:	Mineralogy Laboratory	1
	89-301:	Optical Mineralogy	3
	89-303:	Optical Mineralogy Laboratory	1
	89-304:	Igneous and Metamorphic Petrology	3
	89-306:	Igneous and Metamorphic Petrology Laboratory	1
	89-316:	Geomorphology	3
	89-318:	Geomorphology Laboratory	1
	89-322:	Structural Geology	3
	89-324:	Structural Geology Laboratory	1
	89-352	Stratigraphy & Sedimentation	3
	89-354	Stratigraphy & Sedimentation Laboratory	1
	Geology Elective		3
	89-326:	Glacial and Pleistocene Geology or	
	89-431:	Regional Geology or	
	89-452:	Geochemistry	
C	Supporting Sciences and Mathematics		39-43
	1. 92-131:	Calculus B-I or 92-133: Calculus A-I	4
	92-132	Calculus B-II or 92-134: Calculus A-II, and one additional mathematics course	7-8
	2. 83-101, 103:	Life Science I and Laboratory,	4
	83-102, 104:	Life Science II and Laboratory or	4
	81-111, 113:	Principles of Biology I and Laboratory,	(4)
	81-112, 114:	Principles of Biology II and Laboratory	(4)
	3. 84:121, 123:	Chemistry and Chemistry Laboratory plus	4
	84-122, 123:	Chemical Principles and Laboratory or	4
	84-126, 124:	Chemistry and Chemistry Laboratory	(4)
	4. 95-201, 202 and 96-201, 202:	Principles of Physics and Laboratory or	8
	95-141, 144, 245 and 96-141, 144, 245:	Physics and Laboratory	(11)
	5. 89-121, 123:	Physical Geology and Laboratory	4
III	Unrestricted Elective Courses		3-12
IV	Minimum Credit Requirement		125

SAMPLE COURSE OF STUDY FOR ENVIRONMENTAL SCIENCES—GEOLOGY OPTION
(Bachelor of Science Degree)

Freshman Year

Fall Semester

42-101	College Writing	3
84-121	Chemistry	3
84-123	Chemistry Laboratory	1
92-131	Calculus B-I	4
89-121	Physical Geology	3
89-123	Physical Geology Laboratory	1
87-101	Introduction to Environmental Science	1
39	Physical Education	1
		17

Spring Semester

42-102	College Writing & Literature	3
84-122	Chemistry	3
84-124	Chemistry Laboratory	1
87-102	Foundations of Conservation	3
92-132	Calculus B-II	4
	Elective (Area I or II)	3
39	Physical Education	1
		18

Sophomore Year

Fall Semester

81-111	Principles of Biology I	3
81-113	Principles of Biology I Laboratory	1
95-201	Principles of Physics I	3
96-201	Principles of Physics I Laboratory	1
89-322	Structural Geology	3
89-324	Structural Geology Laboratory	1
92	Mathematics Elective	3-4
		15-16

Spring Semester

81-112	Principles of Biology II	3
81-114	Principles of Biology II Laboratory	1
95-202	Principles of Physics II	3
96-202	Principles of Physics II Laboratory	1
89-315	Hydrogeology	3
89-316	Geomorphology	3
89-318	Geomorphology Laboratory	1
		15

Junior Year

Fall Semester

89-203	Oceanography	3
89-205	Oceanography Laboratory	1
81-315	Principles of Ecology	3
81-317	Principles of Ecology Laboratory	1
89-251	Mineralogy	3
89-253	Mineralogy Laboratory	1
89-208	Paleontology	3
89-210	Paleontology Laboratory	1
		16

Spring Semester

87-232	Atmospheric Science	3
87-234	Atmospheric Science Laboratory	1
89-301	Optical Mineralogy	3
89-303	Optical Mineralogy Laboratory	1
89-352	Stratigraphy & Sedimentation	3
89-354	Stratigraphy & Sedimentation Laboratory	1
	Elective (Area I or II)	3
		15

Senior Year

Fall Semester

87-407	Environmental Science Seminar	3
89-304	Petrology	3
89-306	Petrology Laboratory	1
	Elective (Area I or II)	6
	Elective	3
		16

Spring Semester

	Geology Elective	3
	Elective (Area I or II)	3
	Electives	9
		15

Mathematics

The major in mathematics is designed to provide a sequence of courses which will acquaint the student with the more important general concepts underlying the main brances of modern mathematics and to furnish an adequate foundation for further study in either pure or applied mathematics. The mathematics major is offered under requirements of the College of Pure and Applied Sciences for the Bachelor of Science degree and requires, at a minimum, 74 credits and 20 courses from the offerings of the College. The mathematics major curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs and provides a valuable background for subsequent graduate study in mathematics, in mathematics related disciplines, and in education, and for employment in the fields of business and industry.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified science courses of the Major Field Requirements for Supporting Sciences.

II	Major Field Requirements*			71-76
	A	Mathematics		55-60
		92-131:	Calculus B-I or	4
		92-133:	Calculus A-I	(4)
		92-131:	Calculus B-II or	4
		92-134:	Calculus A-II	(4)
		92-231:	Calculus B-III or	4
		92-233:	Calculus A-III	(3)
		92-211:	Fundamental Concepts	3
		92-232:	Calculus B-IV or	4
		92-234:	Calculus A-IV	(3)
		92-221:	Linear Algebra	3
		92-361:	Computer Programming	2
		92-301	Applied Mathematics I	3
		92-305:	Introduction to Real Analysis I	3

92-311:	Applications to Linear Algebra	3
92-302:	Applied Mathematics II	3
92-306:	Introduction to Real Analysis II	3
92-411:	Complex Variables I	3
92-421:	Abstract Algebra I	3
92	Mathematics Electives	15

B Supporting Sciences 16

84-121:	Chemistry I	3
84-123:	Chemistry Laboratory	1
84-122:	Chemistry II	3
84-124:	Chemistry Laboratory	1
95-141:	Introductory Physics	3
96-141:	Fundamentals of Experimental Physics I	1
95-142:	Concepts of Physics I	3
96-144:	Fundamentals of Experimental Physics II or	1
95-144:	Fundamentals of Physics I	(3)
96-144:	Fundamentals of Experimental Physics II	(1)

* Honors courses in mathematics, chemistry and physics may be substituted.

III Allied Courses 23-28

A Minor Programs

With the approval of their faculty advisors, students may choose a minor of 18-24 credits in some field other than mathematics. A minimum of 6 credits at the "300"-"400" level is required for all minor areas.

B Cognate Programs

With the approval of their faculty advisors, students may choose a program of cognate courses specified by the Department, e.g. actuarial, applied, business, and pure mathematics or computer programming.

IV Minimum Credit Requirement 122

Prerequisites for courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to requirements for a baccalaureate degree in mathematics. All Bachelor of Science programs require, as a minimum, 74 credits and 20 courses from the offerings of the College of Pure and Applied Sciences.

SAMPLE COURSE OF STUDY FOR MATHEMATICS*
(Bachelor of Science Degree)

Freshman Year

Fall Semester

84-121	Chemistry I	3
84-123	Chemistry I Laboratory	1
42-101	College Writing	3
92-133	Calculus A-I	(4)
95-141	Introductory Physics	3
96-141	Fundamentals of Experimental Physics	1
39	Physical Education	1
		16

Spring Semester

84-122	Chemistry II	3
84-124	Chemistry II Laboratory	1
42-102	College Writing & Literature	3
92-132	Calculus B-II or	4
92-134	Calculus A-II	(4)
95-142	Concepts of Physics I	3
96-144	Fundamentals of Experimental Physics II	1
39	Physical Education	1
		16

Sophomore Year

Fall Semester

92-231	Calculus B-III or	4
92-233	Calculus A-III	(3)
92-211	Fundamental Concepts	3
	Elective (Area I)	3
	Elective (Non-Math)	3
	Elective	3
		15-16

Spring Semester

92-232	Calculus B-IV or	4
92-234	Calculus A-IV	(3)
92-221	Linear Algebra	3
92-361	Computer Programming	2
	Elective (Area II)	3
	Elective (Non-Math)	3
	Elective	(3)
		15-18

Junior Year

Fall Semester

92-301	Applied Mathematics I	3
92-305	Introduction to Real Analysis I	3
92-311	Applications of Linear Algebra	3
	Elective (Area I)	3
	Elective (Non-Math)	3
		15

Spring Semester

92-302	Applied Mathematics II	3
92-306	Introduction to Real Analysis II	3
92	Mathematics Elective	3
	Elective (Area II)	3
	Elective	3
		15

Senior Year

Fall Semester

92-411	Complex Variables I	3
92-421	Abstract Algebra I	3
92	Mathematics Elective	3
	Elective (Area I or II)	3
	Elective	3
		15

Spring Semester

92	Mathematics Elective	3
92	Mathematics Elective	3
92	Mathematics Elective	3
	Elective (Non-Math)	3
	Elective (Non-Math)	3
		15

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* Cf. Summary of Degree Requirements for listing of approved alternative courses.

Meteorology

The meteorology major is offered under the requirements of the College of Pure and Applied Sciences for the Bachelor of Science degree. The goal of the meteorology program is to provide students with a knowledge of the fundamental principles and techniques of physics and mathematics which is necessary for understanding atmospheric behavior and for solving practical problems concerning weather and climate. Because meteorology is primarily the application of the principles and techniques of physical sciences to the study of the atmosphere, the meteorology curriculum specifies a substantial core of supporting science and mathematics courses. In order to be admitted to the meteorology major at the beginning of the sophomore year, a student must have a cumulative grade-point average of a least 2.00 for the specified freshman curriculum and grades of at least "C" in each of the specified freshman mathematics and physics courses.

The work of the meteorologist is concentrated on the effort to understand the physical causes of weather and climate and to apply this knowledge to the solution of practical problems ranging from the forecasting of weather to the analysis of the influence of weather and climate on public health, agriculture, engineering, industry and commerce, and national defense. Meteorologists are employed by the agencies of the federal government, the National Oceanic and Atmospheric Administration, the National Weather Service, and the Department of Defense, as well as by agencies of state and local governments and by commercial aviation companies and private consulting firms. Meteorology students who wish to continue their studies at the graduate level are advised to develop competencies in science and mathematics beyond those which are mandated by the supporting science and mathematics core.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

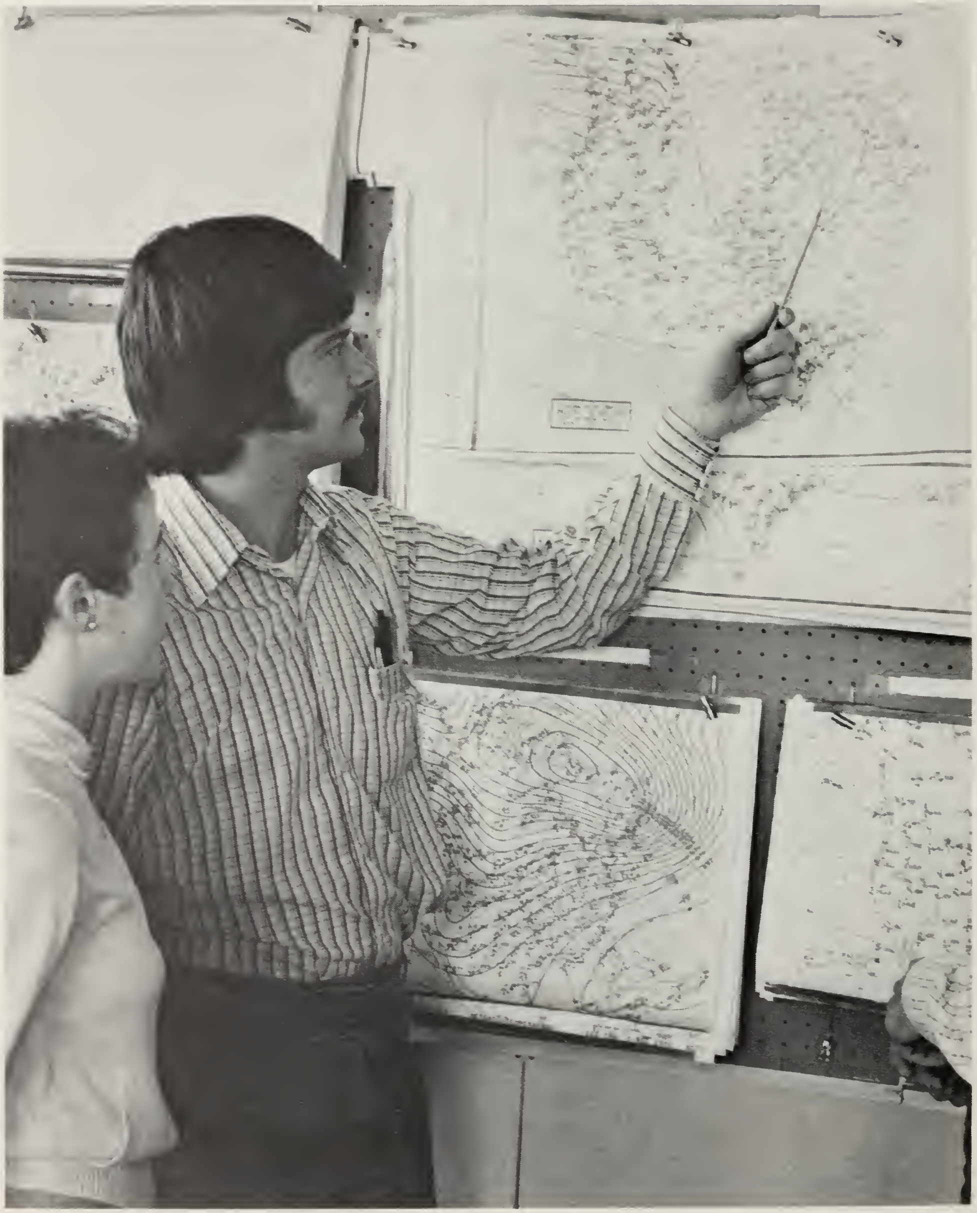
+ Area III requirement is satisfied by specified science and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II	Major Field Requirements		82-84
A	Meteorology		33
	93-211:	Elementary Meteorology I	3
	93-212:	Elementary Meteorology II	3
	93-301:	Atmospheric Dynamics I	3
	93-302:	Atmospheric Dynamics II	3
	93-308:	Synoptic Meteorology	3
	93-313:	Physical Climatology	3
	93-403:	Physical Meteorology	3
	93-415:	Advanced Atmospheric Dynamics	3
	93-421:	Analysis and Forecasting I	3
	93-422:	Analysis and Forecasting II	3
	93-430:	Atmospheric Diffusion	3
B	Chemistry		8
	84-121	Chemistry	3
	84-123:	Chemistry Laboratory	1
	84-122:	Chemistry	3
	84-124:	Chemistry Laboratory	1
C	Mathematics		25-27
	92-131:	Calculus B-I	4
	92-133:	Calculus A-I	(4)
	92-132	Calculus B-II	4
	92-134:	Calculus A-II	(4)
	92-231:	Calculus B-III	4
	92-233:	Calculus A-III	(3)
	92-232:	Calculus B-IV	4
	92-234:	Calculus A-IV	(3)
	92-301:	Applied Mathematics I	3
	92-302:	Applied Mathematics II	3
	92-361:	Digital Computer Programming	2
	92-383:	Introduction to Statistics	3
D	Physics		16
	95-141:	Introductory Physics	3
	96-141:	Fundamentals of Experimental Physics I	1
	95-144:	Fundamentals of Physics I	3
	96-144	Fundamentals of Experimental Physics II	1
	95-245:	Fundamentals of Physics II	3
	96-245:	Fundamentals of Experimental Physics III	1
	95-246:	Special Topics in Physics	4
	96-246:	Fundamentals of Experimental Physics IV	1
III	Science or Engineering Electives		16-18

The Major Field Requirements permit students to elect limited programs for the purpose of developing specific interests. In consultation with their advisors, students may choose a minor, additional elective courses in meteorology, science, and mathematics, or may elect the following engineering courses as preparation for various fields allied with meteorology. A minimum of 6 credits at the "300" - "400" level is required for all minors.

14-301:	Hydraulics	4
14-460:	Water Resources Engineering	4
16-211:	Fundamentals of Electricity	3
16-212:	Introductory Electronics	3
22-242:	Thermodynamics	3
22-343:	Heat Transfer	3
22-382:	Fluid Mechanics	3
22-483:	Aerodynamics	3
18-523:	Air Resources	3

IV Minimum Credit Requirement 123



SAMPLE COURSE OF STUDY FOR METEOROLOGY
(Bachelor of Science Degree)

Freshman Year

Fall Semester

84-121	Chemistry	3
84-123	Chemistry Laboratory	1
* 92-131	Calculus B-1	4
95-141	Introductory Physics	3
96-141	Fundamentals of Experimental Physics	1
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

84-122	Chemistry	3
84-124	Chemistry Laboratory	1
* 92-132	Calculus B-II	4
95-144	Fundamentals of Physics	3
96-144	Fundamentals of Experimental Physics II	1
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

* 92-231	Calculus B-III	4
92-361	Digital Computer Programming	2
92-211	Elementary Meteorology	3
95-245	Fundamentals of Physics II	3
96-245	Fundamentals of Experimental Physics III	1
	Elective (Area I or II)	3
		16

Spring Semester

* 92-232	Calculus B-IV or	4
92-383	Introduction to Statistics	3
93-212	Elementary Meteorology	3
95-246	Special Topics in Physics	4
96-246	Fundamentals of Experimental Physics IV	1
	Elective (Area I or II)	3
		18

Junior Year

Fall Semester

92-301	Applied Mathematics I	3
93-301	Atmospheric Dynamics	3
93-308	Synoptic Meteorology	3
	Elective (Area I or II)	3
	Elective (Science or Engineering)	3-4
		15-16

Spring Semester

92-302	Applied Mathematics II	3
93-302	Atmospheric Dynamics	3
93-313	Physical Climatology	3
	Elective (Area I or II)	3
	Elective (Science or Engineering)	3-4
		15-16

Senior Year

Fall Semester

93-403	Physical Meteorology	3
93-415	Advanced Atmospheric Dynamics	3
93-421	Analysis & Forecasting	3
	Elective (Area I or II)	3
	Elective (Science or Engineering)	3-4
		15-16

Spring Semester

93-422	Analysis and Forecasting	3
93-430	Atmospheric Diffusion	3
	Electives (Science or Engineering)	6-8
	Elective	3
		15-17

* Cf. Summary of Degree Requirements for listings of approved alternative courses.

Physics is the study of the fundamental laws of nature which govern the behavior of all matter. The major serves a variety of goals and interests and provides a broad, comprehensive background in both experimental and theoretical physics which will prove useful for science-oriented careers in business and industry, for subsequent graduate work in professional schools of business, education, law, medicine, and public administration, and for continued study at the master's and doctor's levels. Because of the precise and theoretical nature of physics, students who plan to major in this discipline must possess a high degree of mathematical competence.

Program options permit the student to select a structured curriculum in pure physics which provides rigorous training in both theoretical and experimental physics or a more flexible curriculum in applied physics which permits the student to apply his or her knowledge of physics to another science or to technological and professional fields. Both the pure and applied physics options provide the essential content of undergraduate physics and successful completion of either program will provide good preparation for graduate work in physics or in one of the fields in which the student may wish to apply his or her physics knowledge.

The applied physics option provides the student who has a clear understanding of career objectives with an early opportunity to integrate personal goals with the study of physics and undoubtedly will have immediate relevancy for the student who desires to pursue a career in research and development or who wishes to initiate graduate studies in any of the applied physics disciplines following the completion of undergraduate studies.

The pure physics option provides the student with a competitive advantage in areas of physics which deal with both theoretical and experimental concepts and hence may prove more immediately valuable to the student who, following graduation, desires to initiate graduate work in physics or to pursue a career in which a broad theoretical and experimental background in physics is required.

Both the pure and applied physics curricula involve a common freshman year, at the end of which the student normally is expected to consult his or her faculty advisor and to make a choice of program. The physics major is offered under the requirements of the College of Pure and Applied Sciences for the Bachelor of Science degree. A grade-point average of 2.00 or better is required in physics (courses with prefixes of "80", "95", and "96") for graduation.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional

three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified science and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

# Six credits in a single foreign language (French, German, or Russian) are required of students electing the pure physics option.

II	Option in Pure Physics	102
A	Major Field Requirements	84
1.	Physics	60
95-141:	Introductory Physics	3
96-141:	Fundamentals of Experimental Physics I	1
95-144:	Fundamentals of Physics I	3
96-144:	Fundamentals of Experimental Physics II	1
95-209:	Electricity and Magnetism	4
95-210:	Introductory Modern Physics	4
95-238:	Optics and Waves	2
96-257	Physical Instrumentation	2
96-293:	Experimental Physics I	3
96-294:	Experimental Physics II	3
95-308:	Mathematical Techniques of Physics	4
95-313	Mechanics	4
95-335:	Introductory Quantum Mechanics I	3
95-336:	Introductory Quantum Mechanics II	3
95-353:	Electromagnetism I	3
95-354:	Electromagnetism II	3
96-393:	Intermediate Physics Laboratory I	2
96-394	Intermediate Physics Laboratory II	2
95-421:	Statistical Thermodynamics	4
95-461:	Topics in Nuclear Physics	3
95-472:	Topics in Solid State Physics	3
2.	Chemistry	8
84-121:	Chemistry	3
84-123:	Chemistry Laboratory	1
84-126:	Chemistry	3
84-124:	Chemistry Laboratory or	1
84-135:	Honors Chemistry	(3)
84-137:	Honors Chemistry Laboratory	(1)
84-136:	Honors Chemistry	(3)
84-138:	Honors Chemistry Laboratory	(1)

3.	Mathematics	16

92-131:	Calculus B-I or	4
92-133:	Calculus A-I	(4)
92-132:	Calculus B-II	4
92-134:	Calculus A-II	(4)
92-207:	Mathematical Techniques of Physics I	4
92-208:	Mathematical Techniques of Physics II	4

B.	Elective Courses	18

Upon the approval of faculty advisors, students may elect courses from among the offerings of the University which are suitable to their needs and interests. At least 3 credits must be elected from course offerings in behavioral & social sciences, fine arts, and humanities. These credits are in excess of those which are presented for Area I and II of the University Core Requirements.

III	Option in Applied Physics	102
A	Major Field Requirements	72
1.	Applied Physics	48

95-141:	Introductory Physics	3
96-141:	Fundamentals of Experimental Physics I	1
95-144:	Fundamentals of Physics I	3
96-144:	Fundamentals of Experimental Physics II	1
95-245:	Fundamentals of Physics II	3
95-246:	Special Topics in Physics	4
96-257:	Physical Instrumentation	2
96-293:	Experimental Physics I	3
96-294:	Experimental Physics II	3
96-393:	Intermediate Physics Laboratory I	2
96-394:	Intermediate Physics Laboratory II	2
95-421:	Statistical Thermodynamics	4
80-311:	Applied Mechanics	4
80-335:	Applied Modern Physics I	3
80-336:	Applied Modern Physics II	3
80-354:	Applied Electromagnetism	4
80-397:	Computer Programming & Applications I	3

2.	Chemistry	8

84-121:	Chemistry	3
84-123:	Chemistry Laboratory	1
84-126:	Chemistry	3
84-124:	Chemistry Laboratory or	1
84-135:	Honors Chemistry	(3)
84-137:	Honors Chemistry Laboratory	(1)
84-136:	Honors Chemistry	(3)
84-138:	Honors Chemistry Laboratory	(1)

3. Mathematics 16

92-131:	Calculus B-I or	4
92-133:	Calculus A-I	(4)
92-132:	Calculus B-II	4
92-134:	Calculus A-II	(4)
92-207:	Mathematical Techniques of Physics I	4
92-208:	Mathematical Techniques of Physics II	4

B. Elective Courses 30

Upon the approval of their faculty advisors, students may elect courses from among the offerings of the University which are suitable to their needs and interests. At least one elective must be in a science area (other than physics) or in mathematics. At least one elective must be selected from the course offerings in behavioral & social sciences, fine arts, and humanities. Students electing the Applied Physics option are also required to complete 18 credits in a supplementary field (e.g. biology, chemistry, geology, engineering, technology, or business administration).

IV Minimum Credit Requirement 125

Prerequisites for courses of the Major Field Requirements, or courses which are prerequisites for admission to the College of Pure and Applied Sciences, may not be credited to requirements for degrees in the College of Pure and Applied Sciences. All Bachelor of Science programs require, as a minimum, 74 credits and 20 courses from the offerings of the College of Pure and Applied Sciences.

SAMPLE COURSE OF STUDY FOR PHYSICS — PURE PHYSICS OPTION
(Bachelor of Science Degree)

Freshman Year

Fall Semester

* 84-121	Chemistry	3
* 84-123	Chemistry Laboratory	1
* 92-131	Calculus B-1	4
+ 95-141	Introductory Physics	3
+ 96-141	Fundamentals of Experimental Physics I	1
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

* 84-126	Chemistry	3
* 84-124	Chemistry Laboratory	1
* 92-132	Calculus B-II	4
+ 95-144	Fundamentals of Physics I	3
+ 96-144	Fundamentals of Experimental Physics II	1
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

92-207	Mathematical Techniques of Physics I	4
95-209	Electricity and Magnetism	4
96-293	Experimental Physics I	3
96-257	Physical Instrumentation	2
	Elective	3
		16

Spring Semester

92-208	Mathematical Techniques of Physics II	4
95-210	Introductory Modern Physics	4
95-238	Optics and Waves	2
96-294	Experimental Physics II	3
	Elective	3
		16

Junior Year

Fall Semester

95-313	Mechanics	4
95-335	Introductory Quantum Mechanics I	3
95-353	Electromagnetism I	3
96-393	Intermediate Physics Laboratory I	2
	Elective	3
		15

Spring Semester

95-308	Mathematical Techniques of Physics III	4
95-336	Introductory Quantum Mechanics II	3
95-354	Electromagnetism II	3
96-394	Intermediate Physics Laboratory II	2
	Elective	3
		15

Senior Year

Fall Semester

95-421	Statistical Thermodynamics	4
95-461	Topics in Nuclear Physics	3
	Electives	9
		16

Spring Semester

95-472	Topics in Solid State Physics	3
	Electives	12
		15

* Cf. Summary of Degree Requirements for listings of approved alternative courses.
+ Appropriate honors courses may be substituted.

SAMPLE COURSE OF STUDY FOR PHYSICS — APPLIED PHYSICS OPTION
(Bachelor of Science Degree)

Freshman Year

Fall Semester

* 84-121	Chemistry	3
* 84-123	Chemistry Laboratory	1
* 92-131	Calculus B-I	4
+ 95-141	Introductory Physics	3
+ 96-141	Fundamentals of Experimental Physics I	1
42-101	College Writing	3
39	Physical Education	1
		16

Spring Semester

* 84-126	Chemistry	3
* 84-124	Chemistry Laboratory	1
* 92-132	Calculus B-II	4
+ 96-144	Fundamentals of Experimental Physics II	1
+ 95-144	Fundamentals of Physics I	3
42-102	College Writing & Literature	3
39	Physical Education	1
		16

Sophomore Year

Fall Semester

92-207	Mathematical Techniques of Physics I	4
95-245	Fundamentals of Physics II	3
95-257	Physical Instrumentation	2
96-293	Experimental Physics I	3
	Elective	3
		15

Spring Semester

92-208	Mathematical Techniques of Physics II	4
95-246	Special Topics in Physics	4
96-294	Experimental Physics II	3
	Elective	3
	Elective	3
		17

Junior Year

Fall Semester

80-311	Applied Mechanics	4
80-335	Applied Modern Physics I	3
96-393	Intermediate Physics Laboratory I	2
	Elective	3
	Elective	3
		15

Spring Semester

80-354	Applied Electromagnetism	4
80-336	Applied Modern Physics II	3
96-394	Intermediate Physics Laboratory II	2
	Elective	3
	Elective	3
		15

Senior Year

Fall Semester

95-421	Statistical Thermodynamics	4
80-397	Computer Programming	3
	Electives	9
		16

Spring Semester

	Electives	15

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* Cf. Summary of Degree Requirements for listings of approved alternative courses.

+ Appropriate honors courses may be substituted.

# A different thermodynamics course may be substituted with the consent of the faculty advisor.

Radiological Health Physics

The radiological health physics program is designed to provide needed professional personnel to assist in the advancement of the safe utilization of nuclear energy and radiation. The academic program, which is broadly based in the sciences and includes specialized training and internship programs, stresses the complex interrelationships of scientific knowledges and technological skills which are fundamental to the solution of problems of radiation safety and control. Summer programs, which are established in cooperation with nuclear and radiation facilities of the University of Lowell, government laboratories, industries, and major hospitals, provide experience with equipment and methods which are characteristic of current techniques and philosophies of professional practice in the radiation protection field and assist students in selecting professional positions after graduation or in determining areas of interest for advanced graduate work or research.

SUMMARY OF DEGREE REQUIREMENTS

I	University Core Requirements	23
	Physical Education	2
	English Composition	6
	Area I (Behavioral & Social Sciences)	6-9*
	Area II (Fine Arts & Humanities)	6-9*
	Area III (Mathematics & Sciences)	(12)+

* A minimum of two courses and six credits must be presented in each of the three areas of the University Core Requirements. An additional three courses and nine credits must be presented from among the three areas of the University Core Requirements. Students may not present more than three courses and nine credits from the offerings of any one department (except that not more than two courses and six credits may be presented from the offerings of the English Department) and may not present more than four courses and twelve credits in any one distribution area.

+ Area III requirement is satisfied by specified science and mathematics courses of the Major Field Requirements for Supporting Sciences & Mathematics.

II	Major Field Requirements			74-76
	A	Radiological Health Physics		39
		95-141:	Introduction to Physics	3
		96-141:	Fundamentals of Experimental Physics I	1
		95-144:	Fundamentals of Physics I	3
		96-144:	Fundamentals of Experimental Physics II	1
		95-245:	Fundamentals of Physics II	3
		96-245:	Fundamentals of Experimental Physics III	1
		95-246:	Special Topics in Physics	4
		98-101	Introduction to Radiological Sciences I	1
		98-102:	Introduction to Radiological Sciences II	1
		98-401:	Radiation Safety and Control I	3
		98-403:	Numerical Laboratory in Radiation Safety	1

	98-402	Radiation Safety and Control II	4
	98-422:	Environmental Radiation & Nuclear Site Criteria	3
	80-201:	Physics of Radiation	3
	80-202:	Physics of Nuclei	3
	80-206:	Nuclear Instrumentation I	4
B	Supporting Sciences and Mathematics		35-37
	84-121:	Chemistry	3
	84-123:	Chemistry Laboratory	1
	84-126:	Chemistry	3
	84-124:	Chemistry Laboratory	1
	84-484:	Radiochemistry	3
	81-111:	Principles of Biology I	3
	81-112:	Principles of Biology II	3
	81-252:	Mammalian Physiology	3
	81-254:	Mammalian Physiology Laboratory	1
	81-462:	Radiation Biology	3
	92-133:	Calculus A-I or	4
	92-131	Calculus B-I	(4)
	92-134:	Calculus A-II or	4
	92-132:	Calculus B-II	(4)
	92-233:	Calculus A-III or	3
	92-231:	Calculus B-III	(4)
	92-234:	Calculus A-IV or	3
	92-232:	Calculus B-IV	(4)
III	Allied Courses and Electives		23-25
	42-112:	Technical & Scientific Communication	3
		Electives	20-22
IV	Minimum Credit Requirement		122

SAMPLE COURSE OF STUDY FOR RADIOLOGICAL HEALTH PHYSICS
(Bachelor of Science Degree)

Freshman Year

Fall Semester

42-101	College Writing	3
84-121	Chemistry	3
84-123	Chemistry Laboratory	1
* 92-133	Calculus A-I	4
95-141	Introductory Physics	3
96-141	Fundamentals of Experimental Physics I	1
98-101	Introduction to Radiological Sciences I	1
39	Physical Education	1
		17

Spring Semester

42-102	College Writing & LIterature	3
84-126	Chemistry	3
84-124	Chemistry Laboratory	1
* 92-134	Calculus A-II	4
95-144	Fundamentals of Physics I	3
96-144	Fundamentals of Experimental Physics II	1
98-102	Introduction to Radiological Sciences II	1
39	Physical Education	1
		17

Sophomore Year

Fall Semester

80-201	Physics of Radiation	3
81-111	Principles of Biology I	3
16-211	Fundamentals of Electricity	3
* 92-233	Calculus A-III	3
95-245	Fundamentals of Physics II	3
96-245	Fundamentals of Experimental Physics III	1
		16

Spring Semester

80-202	Physics of Nuclei	3
81-112	Principles of Biology II	3
80-206	Nuclear Instrumentation I	4
* 92-234	Calculus A-IV	3
95-246	Special Topics in Physics	4
		17

Junior Year

Fall Semester

98-401	Radiation Safety & Control	3
98-403	Numerical Laboratory in Radiation Safety & Control	1
80-305	Nuclear Instrumentation II	4
42-112	Technical & Scientific Communication	3
	Elective	3
		14

Spring Semester

81-252	Mammalian Physiology	3
81-254	Mammalian Physiology Laboratory	1
98-402	Radiation Safety & Control II	4
	Elective (Area I)	3
	Elective (Area II)	3
	Elective	3
		17

Senior Year

Fall Semester

	Elective (Area I)	3
	Elective (Area II)	3
	Elective (Area I or II)	3
	Electives	6
		15

Spring Semester

81-462	Radiation Biology	3
84-484	Radiochemistry	3
98-422	Environmental Radiation	3
	Electives	6
		15

* Cf. Summary of Degree Requirements for listings of approved alternative courses.

MINOR PROGRAMS

Minor areas of study which are offered by the College of Pure and Applied Sciences are noted below. Science majors may wish to consider these minors, other minors which are offered by the College of Liberal Arts, the College of Management Science, the College of Music, and specialized course sequences of the College of Engineering. All minor programs of the University require 18-24 credits, 6 of which must be at the “300”-“400” level.

Biology

A minor in biology consists of the following:

a. A year sequence of a course in introductory biology with a laboratory component. This requirement may be satisfied by electing the lecture and laboratory sections in either the Principles of Biology or Life Science.

b. Four additional 3 or 4 credit courses offered by the Department of Biological Sciences with an “81” prefix. Two of these courses must have a laboratory component.

Chemistry

A minor in chemistry consists of 18-24 credits in chemistry, exclusive of any course work taken to satisfy the Area III requirement. All course prerequisites must be satisfied. The course requirements for the chemistry minor are as follows:

a. A freshman level course, (84-121, 123 and 84-126, 124) or the equivalent must be included.

b. Beyond the required freshman level course, four additional courses are required, of which not more than two of these courses may be from the same chemistry area.

c. At least two (2) courses must carry a laboratory component, exclusive of 84-121, 123 and 84-126, 124 or its equivalent.

d. A lecture course with a corresponding separate laboratory course will be considered as one course for the additional course requirement.

e. At least eight semester hours must be taken at or above the “300” course level.

Geology

A minor in geology consists of 89-121: Physical Geology and five courses from the following listing, two of which must be at the “300 level or above.

89-208: Paleontology
89-251: Mineralogy
89-301: Optical Mineralogy
89-304: Igneous and Metamorphic Petrology
89-314: Hydrogeology
89-316: Geomorphology
89-322 Structural Geology

89-324: Glacial and Pleistocene Geology
89-352: Stratigraphy and Sedimentation
89-452: Geochemistry

Mathematics

The Department of Mathematics expects that all students electing the mathematics minor will develop a mathematics proficiency above and beyond that which is required by their major field of study. A minor in mathematics consists of 18-24 credits, 12 of which credits must have been earned by completing departmentally approved courses.

Physics

A minor in physics consists of 24 credits and must include either Sequence I or II as specified below plus additional courses from Sequence III and a minimum of 6 credits from course offerings in physics at the "300"-"400" level.

Sequence I: 95-141, 96-141, 95-144, 96-144, 95-245, and 96-245

Sequence II: 95-147, 96-147, 95-148, 96-148, 95-247, and 96-245

Sequence III: 95-246 or 248, 95-238, 96-257, 96-293, 96-294, 80-201, 80-202, 80-206

COURSE DESCRIPTIONS

Each course offering is designated by a two-digit college prefix and a three-digit course number. The two-digit college prefix identifies a college department and/or special subject area. In some cases the prefix also identifies laboratory or lecture courses and courses which are primarily for majors and minors. The three-digit course number identifies the course level.

COURSE PREFIXES

The following numerical prefixes are assigned to the Department of Aerospace Studies and the seven colleges:

Aerospace Studies	29	Liberal Arts	40-59
Education	01-09	Management Science	60-69
Engineering	10-28	Music	70-79
Health Professions	30-39	Pure & Applied Sciences	80-99

Course prefixes assigned by the College of Pure and Applied Sciences are as follows:

Applied Physics	80	Geology	89
Biological Siciences *	81	Mathematics	92
Biological Sciences +	82	Meteorology	93
Biological Sciences #	83	Physics (Lecture)	95
Chemistry	84	Physics (Laboratory)	96
Environmental Science	87	Polymer Chemistry	97
Geography	88	Radiological Health Physics	98

* Primarily for student majoring or minoring in biological sciences.

+ Primarily for students not majoring or minoring in biological sciences; credit approved for degree but not for major or minor requirements.

# Primarily for student not majoring or minoring in biological sciences; degree credit not approved for majors or minors in biological sciences.

COURSE NUMBERS

Courses numbered 001-049 are prefreshman and special undergraduate courses and do not carry baccalaureate degree credit. Those numbered 100-299 are lower-division undergraduate courses and those numbered 300-499 are upper-division undergraduate courses. The 400 level courses are generally limited to juniors and seniors majoring in a field but are open, with permission, to other advanced undergraduates and to graduate students. Directed studies courses and practicum experience courses are generally limited by departmental policy to students majoring in the area in which such courses are offered. Courses numbered 500-599 are graduate courses which are open to upper-division undergraduates with the consent of instructors and chairpersons. Courses numbered 600-699 are graduate courses which are open only to graduate students. Courses numbered 700-799 designate graduate research projects and graduate theses.

SEMESTER, CLASS, AND CREDIT DESIGNATIONS

Courses which are offered during the fall semester are designated by the Roman Numeral I; spring semester courses are designated by the Roman Numeral II, and courses which are offered during both fall and spring semesters are designated by the Roman numerals I and II. Courses which are not prescheduled for specific semesters carry no Roman numerical designation. In the event that a course is given during the first half of a semester, the Roman number is followed by the letter A. A course which is given during the second half of a semester is followed by the letter B.

Arabic numbers enclosed in parentheses indicate the number of hours of lecture/recitation and of laboratory/applied activity. The Arabic number following the numbers in parentheses is a designation of course credit. For example, the designation IB (6,0) 3 means that a course is offered during the second half of the fall semester, requires 6 hours of lecture/recitation per week, and carries 3 semester credits. Similarly, the designation II (2,6) 4 means that a course is offered during the spring semester, requires 2 hours of lecture/recitation per week and 6 hours of laboratory/applied activity per week, and carries four semester credits.

COURSE RESTRICTIONS

Special course prerequisites, corequisites, and enrollment restrictions are indicated at the end of the course description. A course which is listed as a prerequisite must have been completed and passed prior to taking the course for which the prerequisite is specified. An exception to this limitation may be granted by the designated instructor only. A course which is listed as a corequisite must be taken during the same semester as the course for which the corequisite is specified. Courses which carry such notations as "open for majors only" and "sophomore status required" are restricted to the specified students. Courses which carry the notation "permission of instructor" require instructor approval prior to filing enrollment cards with the Office of Registrar. Courses at the 100-300 levels which do not carry prerequisite, corequisite and enrollment restrictions are open for election by all students unless general restrictions have been listed under the department or course area heading.

INSTRUCTOR DESIGNATION

The instructor who is designated to teach a course for the current academic year may be listed at the end of the course description. Courses which carry no instructor designation are taught by members of the department or by unassigned faculty members.

DEPARTMENT OF BIOLOGICAL SCIENCE

Biological Sciences (Course Prefix 81)

Courses Primarily for Students Majoring or Minoring in Biological Sciences: Approved for Credit Toward Major and Minor Sequences.

81-111 PRINCIPLE OF BIOLOGY I — I, II (3,0) 3

Introduction to biological systems above the unit organismal level. Study of plants and animals with respect to reproduction and development, behavior, genetics, evolution, ecology and biogeography. Corequisite: 81-113 for BS majors and minors. Protopapas.

81-113 PRINCIPLES OF BIOLOGY I LABORATORY — I, II (0,3) 1

A series of laboratory experiments and analyses designed to emphasize the material covered in 81-111. Protopapas.

81-112 PRINCIPLES OF BIOLOGY II — I, II (3,0) 3

An introduction to the structure and function of biological processes at the sub-cellular, cellular, and organismal levels. Discussions include metabolism, growth, differentiation, and physiology of plants and animals. Corequisite: 81-114 for BS majors and minors. Rivera.

81-114 PRINCIPLE OF BIOLOGY II LABORATORY — I, II (0,3) 1

A series of laboratory experiments and analyses designed to emphasize the material covered in 81-112. Rivera.

81-201 GENERAL MICROBIOLOGY — I (3,0) 3

A study of the general properties of bacteria, yeasts, molds, and viruses (anatomy, reproduction, cultivation, metabolism, genetics), a survey of major microbial infections of man (etiological agent, symptoms, antibiotics and chemotherapy), and an examination of the role of the microbes in the environment. Prerequisite: 84-126, 81-111, and 81-112. Corequisite: 81-203 for BS majors. Skare and Eberiel.

81-203 GENERAL MICROBIOLOGY LABORATORY — I (0,3) 1

A series of laboratory exercises covering basic qualitative and quantitative techniques in microbiology. Skare and Eberiel.

81-252 MAMMALIAN PHYSIOLOGY — II (3,0) 3

A comprehensive study into the fundamental mechanisms governing mammalian physiology. The integration of cell physiology into biologic control systems and coordinated body functions, with regard to the maintenance of homeostatis, will be considered in terms of biochemical, cytologic, anatomic and physical principles. In each instance the experimental approach into the derivation of physiologic principles will be presented and areas of further investigation will be emphasized. In all cases, the research aspects will be shown. Prerequisite: 81-111, 81-112. Corequisite: 84-222, 81-254 for BS majors. Rencricca.

81-254 MAMMLIAN PHYSIOLOGY LABORATORY — II (0,3) 1

A series of laboratory exercises and experiments to demonstrate physiologic function with an emphasis on human function. Rencricca.

81-302 DEVELOPMENTAL BIOLOGY II (2,0) 2

Embryology is presented as a single science, integrating morphological and experimental physiological approaches for an understanding of the ontogenetic development of organisms. An introduction to the molecular biology of development is also presented. Prerequisite: 81-111 and 81-112. Corequisite: 81-304. Protopapas.

81-304 EXPERIMENTAL MORPHOGENESIS II (1,3) 2

Lectures include discussion of experimental design and analysis, with emphasis on the critical experiments of developmental biologists. Laboratory investigations deal with problems of cellular differentiation and organogenesis, utilizing techniques of both classical experimental embryology and modern developmental biology. Corequisite: 81-302. Osmolski.

81-306 BIOCHEMISTRY II (3,0) 3

A study of the structure and properties of proteins, nucleic acids, carbohydrates, and lipids which combined with a discussion of elementary enzymology allows for detailed descriptions of degradative and biosynthetic pathways, their integration and regulation. Throughout the course emphasis is on methods and practical application of fundamental information to the solution of problems of current bio-medical interest. Prerequisites: 84-222 and 84-335 recommended. Lynch

81-308 BIOCHEMISTRY LABORATORY II (0,3) 1

A series of laboratory exercises designed to introduce the student to a variety of techiques employed in various areas of biochemistry, and other biomedical sciences. Techniques to be used are: UV/vis spectrophotometry, fluorometry, gas chromatography, gel filtration, thin layer and ion exchange chromatography and liquid scintillation spectrometry. Lynch.

81-310 CELL BIOLOGY II (3,0) 3

A study of the structure and function of living matter at the cellular level of organization. Both biological statics and dynamics are considered with emphasis on the control systems involved with chemical energy transformations, membrane phenomena and protein synthesis. Prerequisites: 81-111, 81-112 and 84-222. Corequisite: 81-312 for BS majors. Osmolski.

81-312 CELL BIOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize materials covered in 81-310. Osmolski.

81-315 PRINCIPLES OF ECOLOGY I (2,0) 2

A series of lectures concerned with interrelationships of organisms with their abiotic environment with emphasis on the New England area. Selected current articles and films will supplement the text. Prerequisites: 81-111, 81-112 or 83-101, 102, 103, 104. Corequisites: 81-317. Lyon.

81-317 PRINCIPLE OF ECOLOGY LABORATORY I (0,4) 2

A series of laboratory exercises to supplement and illustrate lectures of 81-315. Field trips are an integral part of the course involving analysis and sampling of such components as water, soil, invertebrate fauna and characteristic flora. Directed readings, laboratory quizzes, practical exam and oral presentation of a research topic are also integral parts of the course. Lyon.

81-320 BOTANY II (3,0) 3

An introduction to the plant kingdom dealing with the structure, function and diversity of the different plant forms. The cytology, ecology, morphology, physiology and taxonomy of plants is considered. Prerequisites: 81-111, 81-112. Corequisite for BS majors: 81-322. Staff.

81-322 BOTANY LABORATORY II (0,3) 1

Greenhouse and laboratory exercises designed to emphasize material covered in 81-320. Staff.

81-324 GENERAL AND COMPARATIVE VERTEBRATE PHYSIOLOGY II (3,0) 3

A course emphasizing the comparative physiology of the vertebrates on the level of the organ system. General physiological concepts will be covered including material on chronobiology. Among systems treated will be the circulatory, muscular, nervous, digestive and endocrine. Prerequisites: 81-111, 81-112. Corequisite: 81-326, 84-222. Namm.

81-326 GENERAL AND COMPARATIVE VERTEBRATE PHYSIOLOGY LABORATORY II (0,3 1

A series of laboratory exercises which will emphasize the concepts stressed in lecture. Namm.

81-331 QUANTITATIVE ECOLOGY I (3,0) 3

A quantitative presentation of the dynamic processes which influence the distribution and abundance of organisms in the biosphere. Consideration is directed toward field and laboratory investigations of current problems with emphasis on design and analysis of experiments. Energy flow, nutrient cycling, population growth and regulation, species diversity, community homeostasis and systems modeling techniques are examined. Prerequisites: 92-385, 81-111, 81-112. Corequisite: 81-333. Mallett.

81-333 QUANTITATIVE ECOLOGY LABORATORY I (0,3) 1

A series of field and laboratory analyses to determine quantitive relationships between organism and environment. Mallett.

81-335 PRINCIPLES OF GENETICS I (3,0) 3

The theories of both classical and molecular genetics are explored with emphasis on the experimental evidence which has laid the foundation for contemporary understanding of genetics. Included is the nature of the genetic material, gene action, genetic recombination, gene regulation, gene interaction, the production and inheritance of phenotype, behavior of chromosomes, and a detailed study of population genetics and quantitative inheritance. Prerequisites: 81-111, 81-112, 84-222. Corequisite: 81-337 for BS majors. Osmolski.

81-337 PRINCIPLES OF GENETICS LABORATORY I (0,3) 1

Laboratory investigations of the transmission and expression of morphological and physiological characters in both eukaryotic and prokaryotic organisms. Osmolski.

81-371 INTRODUCTION TO MOLECULAR GENETICS I (3,0) 3

This is a comprehensive course which emphasizes the experimental derivation of genetic principles. Approximately two-thirds of the course is devoted to the molecular structure and function of genetic materials while roughly one-third is devoted to transmission, arrangement and rearrangement, control of expression and occurrence. The molecular properties, structure, and arrangement of prokaryotic and eukaryotic DNA and RNA are examined and contrasted. The metabolism of these nucleic acids as it pertains to their destruction, repair, replication, transformation, alteration and mutation, transcription and translation, as well as the control of certain of these events is studied. Selected experiments which have led to the acceptance of genetic theory, as well as experiments which support or detract from such theory, are discussed at length. The discussions include, among other aspects, the limitations imposed by the design of the experiment, the materials, systems and experimental techniques utilized, and the handling and interpretation (s) of the data derived from the experiment. Prerequisites: 81-111, 81-112, and 84-222. Corequisite: 81-373 for BS majors. Macdonald.

81-373 INTRODUCTION TO MOLECULAR GENETICS LABORATORY I (0,3) 1

A series of laboratory exercises designed to emphasize selected material covered in 81-371. Macdonald.

81-401 BIOLOGY PRACTICUM I I (0,3) 1

Through observation, preparation of material and presentation of demonstrations in 83-103 laboratories, the student becomes familiar with the materials and teaching-learning situations in the biological sciences. Hinckley and Staff.

81-402 BIOLOGY PRACTICUM II II (0,3) 1

A continuation of 81-401 with students assigned to laboratories. Hinckley and Staff.

81-411, 412 SENIOR RESEARCH IN BIOLOGY I (0,12) 4; II (0,12) 4

An individual, directed one year research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration is required. A report of the research in the form of a thesis is required. Staff.

81-422 PLANT PHYSIOLOGY II (3,0) 3

A critical study of the physiological processes which occur in living plants, with emphasis on the angiosperms. Topics emphasized are growth and development, water relations, mineral nutrition, respiration, photosynthesis, and nitrogen metabolism, Prerequisite: 84-222. Corequisite: 81-424 for BS majors. Kamien.

81-424 PLANT PHYSIOLOGY LABORATORY II (0,3) 1

A series of laboratory experiments and analyses designed to emphasize material covered in 81-422. Kamien.

81-442 CYTOLOGY II (3,0) 3

Deals with the cytoplasm incorporating the structure of cell membranes and the organelles they define; specialized organelles dealing with energy capture and transduction; some aspects of histochemical and biochemical studies on cytoplasmic organelles at the electron microscopic level. An introduction into cytogenetics and nuclear cytology; a brief discussion of prokaryotic cells. Prerequisite: 81-306. Corequisite: 81-444 for BS majors. Rivera.

81-444 CYTOLOGY LABORATORY II (0,3) 1

Introduction to the optical microscope as an analytical tool. Individual laboratories designed to acquaint the student with the analysis of biological ultrastructure at the optical and electron microscopic level. Rivera.

81-451, 452 SENIOR SEMINAR IN ADVANCED TOPICS I (1,0) 2; II (1,0) 2

Seminar discussion of selected topics of current research interest. An oral seminar presentation as well as a written report are required of all biology seniors. Staff.

81-462 RADIATION BIOLOGY II (3,0) 3

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and latent effects in whole animals and the modification of radiation exposure by physical, chemical and biological factors. Prerequisites: 81-252, 98-441 or equivalent. Rencricca.

81-472 VIROLOGY II (3,0) 3

A study of bacterial, animal, and plant viruses including morphology and structure, serology, biochemistry of the infected cell, viral diseases of man, and oncogenesis. Emphasis is on virus-host interactions viewed at the molecular and genetic level. Prerequisites: 81-306, 81-371. Corequisite: 81-474 for BS majors. Skare.

81-474 VIROLOGY LABORATORY II (0,3) 1

A series of laboratory exercises covering basic techniques in bacterial and animal virology including virus propagation and titration, tissue culture, mutagenesis, and biochemical and biophysical characterization of viruses. Brunovskis.

81-491, 492 SENIOR PROJECT IN BIOLOGY I (0,9) 3; II (0,9) 3

An individual, directed one semester research project taken in the fall and/or spring. Presentation of an acceptable project plan at the time of registration is required. A project report is required. Staff.

81-496 PRACTICUM EXPERIENCE I, II (0,9) 3

A program of campus and/or off-campus experiences which are developed by the student in consultation with a member of the student's major department. Specific requirements will vary, depending upon department policies and the nature of the program undertaken by the student. The intent of the practicum experience is to provided an occasion for investigation of a scientific area and for applying techniques of problem solving and/or skills which are appropriate to the student's major discipline. The practicum experience may not be substituted for a required course in the major. Prerequisite: permission of department chairperson.

Primarily for Graduate Students

81-506 PHYSIOLOGICAL ECOLOGY II (3,0) 3

A consideration of physiological evolutionary and environmental aspects of interactions between organism and environment with special emphasis on homeostatic adaptations to biotic and abiotic environmental fluctuations. Prerequisites: 81-252, 81-331. Corequisite: 81-508 for BS majors. Mallett.

81-508 PHYSIOLOGICAL ECOLOGY LABORATORY II (0,3) 1

A series of laboratory investigations designed to illustrate basic homeostatic adaptations enabling organisms to maintain internal constancy in a variable environment. Mallett.

81-510 LIMNOLOGY II (3,0) 3

An introduction to freshwater as a biogeochemical environment considering the geology, chemistry and physics of inland waters as they affect the ability of the medium to sustain life. Particular attention is addressed to basin and channel morphometry, thermal, photic, hydrologic and solvent properties of the medium. Floral and faunal components of the system are considered from populational and community aspects, evolutionary development and specific adaptations to particular niches in standing and flowing waters. Prerequisites: either 81-331 or 81-315. Mallett.

81-512 LIMNOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize the material covered in 81-510. Mallett.

81-515 IMMUNOBIOLOGY I (3,0) 3

A study dealing with the biology of the immune response with sections on antibody production, reaction with antigen, suppression, tolerance, protection and injury. Prerequisites: 81-201, 81-306. Corequisite: 81-517 for BS majors. Coleman.

81-517 IMMUNOBIOLOGY LABORATORY I (0,3) 1

A series of laboratory exercises dealing with the preparation, isolation and characterization of antigens, antibodies and effector cells. Coleman.

81-518 IMMUNOPARASITOLOGY II (3,0) 3

The principles of animal parasitism are considered. The immunological aspects of the host-parasite relationship are stressed. Prerequisite: 81-515. Coleman.

81-520 IMMUNOPARASITOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize the material covered in 81-518. Coleman.

81-522 ERYTHROPOIESIS II (3,0) 3

Components and physiology of the erythropoietic system. Emphasis will be given to the proliferation and differentiation of hemopoietic stem cells with regard to the regulation and maintenance of homeostasis. Abnormalities and perturbations resulting in diseased conditions will be discussed. Prerequisite: 81-252. Rencricca.

81-524 ERYTHROPOIESIS LABORATORY II (0,6) 2

A series of laboratory exercises and projects to demonstrate basic and advanced techniques in hematology and which emphasize the material covered in 81-522. Corequisite: 81-522. Rencricca.

81-531 CURRENT CONCEPTS IN BIOCHEMISTRY I (3,0) 3

A study concerned primarily wth current research on biochemical mechanisms for the regulation of cellular metabolism. Recent developments in those areas of biochemistry concerned with the structure and function of biological membranes will be examined. Prerequisite: 81-306. Corequisite: 81-533 for BS majors. Lynch.

81-533 CURRENT CONCEPTS IN BIOCHEMISTRY LABORATORY I (0,3) 1

A series of laboratory experiments designed to acquaint the student with modern techniques in biochemistry and to emphasize material covered in 81-531. Lynch

81-541 TOPICS IN CELL BIOLOGY I (3,0) 3

The fundamental structure and function of the cell will be discussed in detail. Some of the topics to be discussed are: the anatomy and biochemistry of cellular membranes; transport mechanisms; systems developed by various life forms for motility; properties of excitable cells; systems of energy capture and transduction. Wherever possible, comparisons between the biology of normal and transformed cells will be made. Prerequisites: 81-306, 81-371. Lynch and Rivera.

81-552 MICROBIAL GENETICS II (3,0) 3

A study of the principles and specialized techniques of genetic manipulation developed in experimental molecular biology with bacteria and viruses. Includes mutagenesis, mutant isolation, strain construction, chromosome transfer mechanisms, and mapping techniques. Prerequisites: 81-201, 81-306, 81-472. Corequisite: 81-554 for BS majors. Skare.

81-554 MICROBIAL GENETICS LABORATORY II (0,3) 1

A series of laboratory experiments designed to illustrate the material covered in 81-552. Skare.

81-561 ELECTRON MICROSCOPY-THEORY I (3,0) 3

An introduction to the theory of electron microscopes and electron optics. Preparation of biological specimens for electron microscopic viewing and photography. Analysis of data obtained with electron microscopic techniques. Applications in biology will be discussed. Prerequisites: 81-306, 81-308, and permission of instructor. Rivera.

81-562 ELECTRON MICROSCOPY-LABORATORY I (0,9) 3

Operation of Scanning and Transmission Electron Microscopes. Project required of all students. Use of ancillary optical equipment. Prerequisites: 81-561 and permission of instructor. Rivera.

81-565 SELECTED TOPICS IN NUTRITIONAL BIOCHEMISTRY I (3,0) 3

This course deals with problems in basic and applied nutrition. Emphasis will be placed on nutrition in higher mammals, especially man. Recent evidence concerning the relationship betweeen nutritional factors and disease states such as atherosclerosis, obesity, cancer, the common cold, and aging will be considered. The methods used for establishing minimum dietary requirements will be critically examined in the light of what is known about mechanisms by which animals adapt to varying supplies of nutrients. Prerequisites: 81-252, 81-306. Lynch.

81-586 CELLULAR IMMUNOLOGY II (3,0) 3

Categories, cells, mediators, signals, interactions and regulation of immunological reactions involving cell-mediated immunity. Prerequisite: 81-515. Coleman.

81-588 CELLULAR IMMUNOLOGY LABORATORY II (0,3) 1

A project laboratory designed to illustrate aspects of material covered in 81-586. Coleman.

81-592 BIOCHEMICAL GENETICS II (3,0) 3

A study of the biochemical structure and function of the eukaryotic genome. Roughly one-half of the course deals with the molecular organization of the genetic material and transcriptional control in the eukaryote. The rest of the course focuses on enzyme and other polymorphisms, quantitative and qualitative variations, the null phenotype and inborn errors of metabolism. Subject areas include an in-depth examination of the structure of the histones and non-histones and their interaction with DNA, DNA sequences, renaturation kinetics, structures of transcripts and mechanisms of transcription, and positive and negative regulatory mechanisms of genetic expression in the eukaryote. Prerequisites: 81-306, 81-371. Corequisite: 81-594 for BS majors. Macdonald.

81-594 BIOCHEMICAL GENETICS LABORATORY II (0,3) 1

A series of laboratory experiments and projects designed to emphasize the material covered in 81-592. Macdonald.

Biology (Course Prefix 82)

Courses Primarily for Students Not Majoring or Minoring in Biological Sciences: Approved for Degree Credit for Students Majoring or Minoring in Biological Sciences But Not for Credit Toward Major or Minor Sequences.

82-215 INTRODUCTION TO MARINE BIOLOGY II (2,0) 2

An introduction to the physical and biological factors in aquatic environments with major consideration given to marine life. Emphasis is on the flora and fauna of New England. Several field trips are required. Prerequisite: 81-111, 81-112 or 83-101, 83-102. Corequisite: 82-217. Hinckley.

82-217 INTRODUCTION TO MARINE BIOLOGY LABORATORY II (0,3) 1

A series of laboratory experiments and field trips designed to emphasize the material covered in 82-215. Hinckley.

82-328 HISTOLOGY II (3,0) 3

An introduction to the microscopic structure of animal tissue with emphasis upon human histology. Laboratory investigation is an integral part of the course. Prerequisite: 81-111 and 81-112. Corequisite: 82-330. Shepherd.

82-330 HISTOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize the material covered in 82-328. Shepherd.

82-342 COMPARATIVE VERTEBRATE ANATOMY II (3,0) 3

A study of the basic similarities and differences of organ systems in the vertebrates, with reference to the fields of embryology, histology, and paleontology. Representative vertebrates are studied in the laboratory. Prerequisites: 81-111 and 81-112. Corequisite: 81-344. Shepherd.

82-344 COMPARATIVE VERTEBRATE ANATOMY LABORATORY II (0,3) 1

A series of exercises designed to emphasize the material covered in 82-342. Shepherd.

82-346 INTRODUCTORY ENTOMOLOGY II (2,0) 2

A survey of the major groups of insects. Topics include their structures, importance, and relationship to man. Prerequisites: 81-111, 81-112 or 83-101, 83-102. Corequisite: 82-348. Lee.

82-348 INTRODUCTORY ENTOMOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize the material covered in 82-346. Lee.

82-347 ORNITHOLOGY II (2,0) 2

This course covers the various aspects of the biology of birds, including their structure, physiology, classification, field and laboratory identification, adaptations, behavior, distribution, ecology, life histories, evolution, and relationship to man, with special emphasis on the avifauna of New England. Prerequisites: 81-111, 81-112 or 83-101, 83-102. Corequisite: 82-349. Shepherd.

82-349 ORNITHOLOGY LABORATORY II (0,3) 1

A series of laboratory exercises designed to emphasize the material covered in 82-347. Shepherd.

82-351 HUMAN SEXUALITY I, II (3,0) 3

Lectures and discussions concerning the biological aspects of human sexuality. Topics include the anatomy and physiology of the reproduction system, sexual development, maleness and femaleness, contraception, abortion, errors, and problems. Three lecture-discussions per week. Kamien and Hinckley.

82-354 WILDLIFE AND ENVIRONMENTAL MANAGEMENT II (3,0) 3

An introduction to some of the concepts and principles applicable to forest and wildlife utilizaton. Esthetic and economic considerations will be discussed and serve as the basis for oral and written presentations. Practical experiences in the laboratory and the field such as census methods, tree classification and skinning methods will supplement lecture material. Prerequisite: 81-315 or 81-331. Lyon.

82-419 PRINCIPLES OF EVOLUTION I (3,0) 3

Drawing knowledge from many different fields of biology this course discusses the evidence, process, and mechanisms of evolution. Topics will include the origin of life and of man, the organization of genetic variability, changes and differentiation in population, mechanisms of speciation, adaptation and natural selection. Prerequisite: 81-335. Lee.

Life Sciences (Course Prefix 83)

Courses For Students Not Majoring or Minoring in Biological Sciences: Not Approved for Degree Credit for Students Majoring or Minoring in Biological Sciences.

83-101 LIFE SCIENCE I I, II (3,0) 3

An introduction to the study of biology which considers the earth's environment as a community in which plants and animals live, interact, and demonstrate the genetic variations which enable them to adapt to changes and to evolve. Man's roles as producer, consumer, polluter and conserver will receive attention. Staff.

83-103 LIFE SCIENCE LABORATORY I I, II (0,2) 1

Laboratory work associated with 83-101. Corequisite: 83-101. Staff.

83-102 LIFE SCIENCE II I, II (3,0) 3

The emphasis in this course will be on cellular and organismal structure, function, reproduction and behavior. Staff.

83-104 LIFE SCIENCE LABORATORY II I, II (0,2) 1

Laboratory work associated with 83-102. Corequisite: 83-102. Staff.

83-214 HUMAN ECOLOGY II (3,0) 3

A course designed to reveal and discuss the increasing problems of over-population in regard to environmental deterioration, living space, limits of natural resources and the adverse effects of man's alteration or destruction of the natural ecosystem. The implications of current literature and news items will be emphasized. Individual oral and written presentations are an integral part of the course. Prerequisite: a year of college biology. Lyon.

83-261 EMERGENCY MEDICAL CARE I I (3,0) 3

This course provides the necessary knowledge and skill to give emergency medical care at the emergency scene. The curriculum covers the basics of understanding the emergency situation, as well as specialized emphasis in respiration and resuscitation, bleeding, wounds and shock, use and care of emergency equipment commonly accepted and employed such as suction machines, oxygen delivery systems, backboards, fracture kits, obstetrical kits, stretchers of various types and light rescue tools. Also taught are management of mentally distrubed patients, and initial care of poison and burn patients along with environmental emergencies. Included in the course are lectures on anatomy and physiology by local physicians. Successful completion of the course prepares the student to take the National Registry Exam for Emergency Medical Technician. Eberiel.

83-262 EMERGENCY MEDICAL CARE II II (3,0) 3

A continuation of 83-261. Prerequisite: 83-261. Eberiel.

DEPARTMENT OF CHEMISTRY

Chemistry (Course Prefix 84)

84-101 INTRODUCTORY CHEMISTRY I (3,0) 3

An introduction to atomic structure, chemical bonding, physical and chemical changes, organic chemistry, with emphasis on the application of the theory to topics such as nuclear chemistry and nuclear power, air pollution, water pollution, food additives, and petroleum products. Smith, Tilden.

84-111 GENERAL CHEMISTRY I (3,3) 4

A survey of the principles of chemistry, with emphasis upon inorganic chemistry; the structure of matter; the quantitative aspects of chemical reactions; solution chemistry including acid-base chemistry and ionic equilibria; and introduction to organic chemistry. Hilton.

84-121 CHEMISTRY I (3,0) 3

An introduction to the basic concepts of Chemistry. Topics include chemical calculations atomic structures, the periodic table, basic bonding theory, solutions, solids, liquids, gases. Lamprey.

84-122 CHEMICAL PRINCIPLES II (3,0) 3

A continuation of 84-121 designed to serve as a terminal course for students requiring only one year of chemistry. Includes applications of both organic and inorganic chemistry in engineering and industry. Prerequisite: 84-121. Griffin.

84-123 CHEMISTRY LABORATORY I (0,3) 1

An experimental study of chemical principles and chemical transformation that is coordinated with topics considered in 84-121. Some of the more important reactions of elements, oxides, acids, bases and salts are examined. Other topics include chemical separation, purification preparation of inorganic salts: Quantitative determinations dealing with the formula of a compound, gas laws, and colligative properties are performed. Careful technique and precise measurements are stressed. Corequisite: 84-121.

84-124 CHEMISTRY LABORATORY II (0,3) 1

A continuation of the laboratory study begun in 84-123 that is coordinated with topics of 84-122 and 84-126. Topics include: thermochemistry, kinetics, spectroscopy, titration, pH equilibrium reactions and constants. Some aqueous solution reactions and organic reactions are examined. Accurate measurements and precise instrumental and apparatus operation are expected. Prerequisites: 84-123. Corequisite: 84-122 or 84-126. Peirent.

84-126 CHEMISTRY II (3,0) 3

A continuation of 84-121 emphasizing concepts useful to those who will directly use chemistry in further education or careers. Topics include thermodynamics, kinetics, equilibrium, acids and bases, electrochemistry, details of covalent bonding theories, and a brief introduction to organic chemistry. Prerequisite: 84-121 or equivalent. Lamprey.

84-135 HONORS CHEMISTRY I (3,0) 3

A course designed for capable students. Periodic relationships and principles of stoichiometry, chemical structure, and states of matter are used to characterize the nature of chemical substances. The chemical reactions of certain inorganic substances are considered. Students are encouraged to contribute ideas, question concepts, and participate in discussions. Prerequisite: invitation or permission of instructor. Corequisite: 84-137. Pierce.

84-136 HONORS CHEMISTRY II (3,0) 3

A continuation of 84-135. States of matter, thermodynamics, solution phenomena, chemical kinetics, chemical equilibrium, electrochemistry, and acid-base phenomena are used to characterize the chemical reactions of both organic and inorganic substances. Students are encouraged to participate in the discussions of course material. Prerequisite: 84-135 or permission of instructor. Corequisite: 84-138. Pierce

84-137 HONORS CHEMISTRY LABORATORY I (0,3) 1

A series of laboratory experiments designed to illustrate the principles discussed in 84-135 and to train the student in the techniques of experimentation. Prerequisite: invitation or permission of instructor. Corequisite: 84-135. Pierce.

84-138 HONORS CHEMISTRY LABORATORY II (0,3) 1

A series of laboratory experiments designed to illustrate the principle discussed in 84-136 and train the student in the techniques of experimentation. Prerequisites: 84-135 and 84-137. Corequisite: 84-136. Pierce.

84-207 INORGANIC CHEMISTRY AND QUALITATIVE ANALYSIS I (3,3) 4

The chemical behavior, structure, methods of preparation and nomenclature of the more common elements and their compounds are discussed. The laboratory is based on the qualitative analysis of these elements and of some common anions. Prerequisites: 84-124, 84-126 or 84-136, 84-138. Lavrakas.

84-221 ORGANIC CHEMISTRY IA I (3,0) 3

The basic principles and reactions which characterize the behavior of carbon compound. Nomenclature and mechanism of reaction of many classes of chemical species will be covered. Emphasis is on broad aspects of theory by which the facts of organic chemistry can be deduced. Primarily for chemistry and biology majors. Prerequisite: 84-122, 84-126, or 84-136. Corequisite: 84-227 or 84-229. Scattergood, Watterson, Tanner.

84-222 ORGANIC CHEMISTRY IIA II (3,0) 3

A continuation of 84-221. Primarily for chemistry and biology majors. Prerequisite: 84-221. Corequisite: 84-228 or 84-230. Scattergood, Tanner.

84-223 ORGANIC CHEMISTRY IB I (3,0) 3

Discussion of structure, classification by functionality, nomenclature, systhesis, reaction mechanisms, and industrial and technological applications of organic compounds. Primarily for students of Technology. Prerequisites: 84-122, 84-126, or 84-136. Corequisites: 84-225 or permission of department chairperson; 10-203 or 26-201. Bannister.

84-224 ORGANIC CHEMISTRY IIB II (3,0) 3

A continuation of first semester subject 84-223. Primarily for students of and Technology. Prerequisite: 84-223. Corequisite: 84-226 or permission of instructor. Bannister.

84-225 ORGANIC CHEMISTRY LABORATORY IB I (0,4) 1

Laboratory work in this course is scheduled to accompany topic presentations in the lecture phase of the course (84-223) and will be devoted to product separation and purification techniques, and methods of synthesis of industrially important compounds. Primarily for Technology majors. Corequisite: 84-223. Bannister.

84-226 ORGANIC CHEMISTRY LABORATORY IIB II (0,4) 1

A continuation of the first semester laboratory course, 84-225. Primarily for Technology majors. Prerequisite: 84-225. Corequisite: 84-224. Bannister.

84-227 ORGANIC CHEMISTRY LABORATORY IA I (0,4) 1

The laboratory work consists of practice in planning and carrying out reactions to form products isolable by distillation. Primarily for chemistry majors and students interested in intensive laboratory training. Corequisite: 84-221. Scattergood.

84-228 ORGANIC CHEMISTRY LABORATORY IIA II (0,4) 1

The laboratory work consists of instruction and practice in planning and successfully carrying out reactions to form solid products isolable by crystallization. Primarily for chemistry majors and students interested in intensive laboratory training. Prerequisite: 84-227. Corequisite: 84-222. Scattergood.

84-229 ORGANIC CHEMISTRY LABORATORY IA I (0,4) 1

Techniques, skills, and heuristic approaches involved in the synthesis, purification and identification of organic compounds. Primarily for biology and life science majors. Corequisite: 84-221. Tanner, Watterson.

84-230 ORGANIC CHEMISTRY LABORATORY IIA II (0,4) 1

A continuation of 84-229. Primarily for biology and life science majors. Prerequisite: 84-229. Corequisite: 84-222. Tanner.

84-252 NUTRITION I (3,0) 3

A study of the science of food, the nutrients and other substances therein, their action, interaction and balance in relation to health and disease and the processes by which the individual ingests, digests, absorbs, transports, utilizes and excretes food substances. Prerequisite: one year of chemistry or 35-252.

84-313 ANALYTICAL CHEMISTRY I I (3,0) 3

This course will focus on the evaluation of analytical data, aqueous and non-aqueous acid-base systems, oxidation reduction and complexation equilibria, solubility and precipitation, solvent extraction, ion-exchange and chromatographic methods. Prerequisite: 84-332. Corequisite: 84-315. Barry

84-314 ANALYTICAL CHEMISTRY II II (3,0) 3

The course will introduce the student to modern instrumental methods of chemical analysis. Included are such topics as ultraviolet, infrared, nuclear magnetic resonance, emission and atomic absorption spectroscopy. Mass spectrometry, thermal and electrochemical methods of analysis will be discussed. Prerequisites: 84-313, and 95-202 or 95-245. Corequisite: 84-316. Barry

84-315 ANALYTICAL CHEMISTRY I LABORATORY I (0,4) 1

Experiments emphasizing the topics presented in 84-313 will be conducted. Corequisite: 84-313. Barry.

84-316 ANALYTICAL CHEMISTRY II LABORATORY II (0,4) 1

Laboratory experiments are designed to complement the coverage of topics in 84-314. Prerequisites: 84-313, 84-315. Corequisite: 84-314. Barry.

84-321 ORGANIC SYNTHESIS LABORATORY I (1,6) 3

This course involves more advanced laboratory work in organic chemistry with emphasis on modern techniques of synthesis and the use of instrumentation. Prerequisite: 84-222 or 84-224. Scattergood.

84-323 PHYSIOLOGICAL CHEMISTRY (3,4) 4

The chemical constitution, function and interrelationship of the molecules of living organisms will be considered. Offered in the Spring. Prerequisite: one year of organic chemistry. Herzberg.

84-324 PRINCIPLES OF ANALYTICAL CHEMISTRY II (3,4) 4

This course is designed to introduce science majors (*other* than chemistry majors) to gravimetric, volumetric and chromatographic analyses, and the various instrumental methods of analysis. Lecture topics are planned so as to give detailed background material for the laboratory experiments. Not open to students who have taken 84-314, 84-316, 84-313, or 84-315. Prerequisites: 84-122 or 84-126; 92-131. Litman.

84-326 BIOINORGANIC CHEMISTRY II (2,0) 2

An introduction to the role of metal ions in biological processes. Properties of metal ions will be discussed an how these contribute to a more detailed understanding of the biological systems in which they are involved. Prerequisite: 84-422 or equivalent. Hilton.

84-332 PHYSICAL CHEMISTRY II (3,3) 4

The 84-332 — 84-333 sequence covers basic physical chemical topics: law of thermodynamics, solutions, chemical and phase equilibria, electro-chemistry, kinetics, and atomic and molecular structure. For chemistry majors only. Prerequisites: 92-231 or 92-233, 84-126 or 84-136. Clough, Kowalak.

84-333 PHYSICAL CHEMISTRY I (3,3) 4

See 84-332. Prerequisite: 84-332. Clough.

84-334 ADVANCED INORGANIC CHEMISTRY II (3,0) 3

An introduction to modern theories of atomic structure and chemical bonding, with emphasis on physical-chemical principles and properties. Considerable time will be spent on Coordination Compounds including topics such as descriptive chemistry, biochemical importance, and ligand field theory. Prerequisite: 84-333. Kowalak.

84-335 PRINCIPLES OF PHYSICAL CHEMISTRY I (3,0) 3

Basic course for biology majors. Emphasis on thermodynamics and properties of solutions. Prerequisites: 92-231 or 92-233, 84-126 or 84-136. Isreal.

84-336 PRINCIPLES OF PHYSICAL CHEMISTRY II II (3,0) 3

Continuation of 84-335, with emphasis on the topics of kinetics, equilibrium, and electrochemistry. Course open to chemical engineering majors who have had an introduction to thermodynamics. Prerequisite: 84-335 and 92-231 or 92-233. Hilton.

84-337 PRINCIPLES OF PHYSICAL CHEMISTRY LABORATORY I (0,3) 1

Laboratory work designed to exemplify principles covered in 84-335. Corequisite: 84-335. Israel.

84-338 PRINCIPLES OF PHYSICAL CHEMISTRY LABORATORY II (0,3) 1

Laboratory work to exemplify principles and application of chemical kinetics, equilibrium and electrochemistry. Corequisite: 84-336. Hilton.

84-339 PHYSICAL CHEMICAL PRINCIPLES II (3,0) 3

A one-term course designed for Plastics Technology majors. Emphasis is on aspects of physical chemistry of importance to polymer science: thermodynamics, solutions, kinetics, and optical methods of analysis. Prerequisites: 84-126 or 84-136, 92-231 or 92-233. Clough.

84-341 PHYSICAL CHEMICAL PRINCIPLES LABORATORY II (0,3) 1

Laboratory work designed to exemplify principles and applications covered in 84-339. Corequisite: 84-339. Clough.

84-342 ORGANIC QUALITATIVE ANALYSIS II (1,6) 3

Methods of identification and characterization of unknown organic substances whose properties have been previously published in the chemical literature. Prerequisite: 84-222 or 84-224.

84-403 INTRODUCTORY POLYMER SCIENCE I I (3,0) 3

An introduction to the physical chemistry of polymers, including molecular weight distribution and averages, polymer solutions, fractionation, methods of molecular weight determination, and structure and properties in the rubbery, glassy and crystalline states. Prerequisites: 84-222 or 84-224, 84-333 or 84-336. A. Blumstein.

84-404 INTRODUCTORY POLYMER SCIENCE II II (3,0) 3

Step and chain growth polymerizations. Kinetics and mechanism. Copolymerization. Ionic and free radical polymerizations. Industrially important polymerization processes. Preparation of industrially important polymers. Prerequisites: 84-222 or 84-224, 84-333 or 84-336. A. Blumstein.

84-405 POLYMER LABORATORY I I (0,4) 1

An introductory laboratory in polymer science concerned with the characterization of polymers. Prerequisites: 84-222 or 84-224, 84-333 or 84-336. R. Blumstein.

84-406 POLYMER LABORATORY II II (0,4) 1

An introductory laboratory in polymer science concerned with the techniques of polymer synthesis. Prerequisites: 84-222 or 84-224, 84-333 or 84-336. R. Blumstein.

84-407 UNDERGRADUATE THESIS I (0,9) 3

Open only to Seniors majoring in chemistry. Research in biochemistry, electrochemistry, and analytical, organic, inorganic, physical, and polymer chemistry. Prerequisite: permission of department chairperson and thesis supervisor. Staff.

84-408 UNDERGRADUATE THESIS II (0,9) 3

A continuation of 84-407. Both semesters must be taken and not more than six credits may be used in meeting degree requirements. Letter grades are given in both semesters. A written thesis is required following the conventional form of introduction, literature survey, results, and conclusions. One copy of the thesis must be filed with the department office. Prerequisite: permission of department chairperson and thesis supervisor. Staff.

84-422 BIOCHEMISTRY II (3,4) 4

A study of the chemistry of biomolecules including thermodynamics, kinetics and mechanism of enzyme action, intermediary metabolism and selected topics of molecular biology. Prerequisites: one year each of organic and physical chemistry.

84-423 ADVANCED ORGANIC CHEMISTRY I (3,0) 3

Extension of introductory organic chemistry. Organic reactions and compounds are discussed in terms of reaction mechanisms, structure-reactivity and stereochemistry. Prerequisite: 84-222 or 84-224. Isaks.

84-424 ADVANCED ORGANIC CHEMISTRY II (3,0) 3

Synthesis of organic molecules. Selected reagents and techniques are discussed with emphasis on the scope and limitations of these reactions. The reaction mechanisms are also discussed. Prerequisite: 84-423 or permission of instructor. Isaks.

84-431G ADVANCED PHYSICAL CHEMISTRY I I (3,0) 3

Open to advanced undergraduate and first-year graduate students in chemistry and related fields. Mainly classical and statistical thermodynamics: principles and applications to systems of chemical interest. The first law and thermochemistry, the second law and entropy, thermodynamic functions and equilibrium conditions, phase and chemical equilibria; statistical ensembles, statistical thermodynamics of gases and crystals, statistical theory of chemical equilibrium and rate processes. Prerequisite: 84-333 or equivalent. Pyun.

84-432G ADVANCED PHYSICAL CHEMISTRY II II (3,0) 3

Open to advanced undergraduate and first-year graduate students. Elementary quantum chemistry: the Schroedinger equation, the harmonic oscillator, the rigid rotor, the hydrogen atom, pertarbation theory, the variation method, many electrom atoms, diatomic molecules, polyatomic molescules. Prerequisite: 84-333 or equivalent. Pyun.

84-434 COLLOID SCIENCE AND ITS ENVIRONMENTAL APPLICATIONS II (3,0) 3

An introduction to the fundamentals of colloid and interface science. Topics discussed include solid/gas, solid/liquid, and liquid/liquid interfaces; association colloids, emulsion suspensions, aerosols and foams. Additional topics include applications of colloid science to environmental problems, flocculation and stability, adsorption and ion exchange, ultrafiltration, reverse osmosis, and electro-kinetic phenomena. Prerequisite: permission of instructor. A. Blumstein.

84-481 RADIOCHEMISTRY I (2,3) 3

An introduction to the fundamentals of radioactivity and radiochemistry; laboratory work is directed to the detection and measurement of radioactivity. Designed primarily for majors in chemistry and allied fields. Prerequisites: 84-314 and 84-316, or permission of instructor. Lavrakas.

84-482 ENVIRONMENTAL AND ANALYTICAL RADIOCHEMISTRY II (2,2) 3

A continuation of 84-481 with emphasis on some analytical and environmental aspects of radiochemistry. Laboratory experiments are performed in neutron activation, isotope dilution, and substoichiometric analyses. Prerequisite: 84-481 or permission of instructor. Lavrakas.

84-484 ELEMENTS OF RADIOCHEMISTRY II (2,2) 3

Chemical principles are reviewed and their applications to radioactivity are discussed. Laboratory experiments are oriented to the use of common separation procedures such as ion-exchange, isotopic precipitation and paper chromatography, for a better understanding of the role of chemistry in the study of radioisotopes. Prerequisites: 84-126 and 84-124 or 84-136 and 84-138. Lavrakas.

Primarily for Graduate Students

84-502 COLOR SCIENCE I (2,3) 3

An analytical course in which the concepts and methods of absorption and reflectance spectrophotometry are applied to the measurement of color perception, color difference, and the prediction of color matching. Encompasses both theoretical and applied practical methods for determining both qualitative and quantative composition of the color producing components in transparent and opaque substratum such as liquids, paper, plastics, and textiles. Instrumental and computer useage for measuring and calculating trichromatic coeficients, color differences and color matching formulations are employed. Prerequisites: 84-313 and 84-222, or 84-224; permission of instructor. Peirent.

84-513 SPECTROSCOPY II (3,0) 3

A presentation of molecular spectra. Molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results. Prerequisite: 84-431 or equivalent. Lipschitz.

84-514 ADVANCED ANALYTICAL CHEMISTRY II (3,0) 3

Advanced topics in equilibrium calculations and determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions. Prerequisite: 84-431 or equivalent. Lipschitz.

84-515 CHEMICAL LITERATURE I (1,2) 2

Use of the chemical library, journals, reference works, patents and other technical publication pertaining to chemical subjects. Exercises are given in finding, assembling and using data found in the literature.

84-516 ADVANCED LABORATORY TECHNIQUE II (1,6) 3

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic and inorganic compounds including high efficiency vacuum distillation, hydrogenation reactions in inert atmospheres. The student will be expected to master analytical techniques which involve the "hands on" use i.r., nmr, glc, tlc and other instrumental methods of product identification. Prerequisites: 84-523 and permission of instructor. Isaks.

84-517 GLASS WORKING I (1,3) 1

Fundamental techniques in the preparation and assembling of glass apparatus. The student will practice the art and science of scientific glass blowing. Skill in the assembly of simple scientific glass apparatus will be stressed. Open to all students with permission of instructor.

84-519 ENVIRONMENTAL CHEMISTRY I (3,0) 3

The course topics will be aimed at all science majors and are designed to show the chemistry of various environmental problems. Air, soil and water pollution, mechanisms of pollutant transport and chemical change of pollutants will comprise the major portion of the semester. The remainder of the semester will concern itself with special topics such as nuclear energy, energy sources, water purification, etc. Several field trips in addition to the lecture hours will be arranged throughout the semester. Prerequisites: 84-314 or equivalent; 92-134 or equivalent (with permission). Litman.

84-521 PHYSICAL ORGANIC CHEMISTRY I (3,0) 3

Modern and classical methodology in the study of organic reactions. Fast reactions, linear free energy relationships, instrumental techniques and other selected topics will be covered. Prerequisite: 84-523, 84-524 or equivalent. Offered in alternate years. Isaks.

84-523 ORGANIC REACTION MECHANISMS AND STRUCTURES I (3,0) 3

Designed to provide insight into how reactions occur and how reaction mechanisms are studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry and conformational analysis. For graduate students. Isaks.

84-524 ORGANIC SYNTHESIS II (3,0) 3

Mechanism, scope and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, alkylation, halogenation and acylation. Prerequisite: 84-523 or permission of instructor. For graduate students. Isaks.

84-526 CHROMATOGRAPHIC SEPARATIONS II (3,0) 3

A treatment of the theory underlying chromatographic separations. Included are such topics as gas-liquid, gas-solid, thin layer, paper and high speed liquid chromatography. Application of the various chromatographic methods are discussed. Prerequisite: 84-232 or permission of instructor. Barry.

84-527 STEREOCHEMISTRY I (3,0) 3

The fundamental concepts of symmetry and optical activity. The relationship of stereostructures to the physical and chemical properties of organic compounds. Offerd in alternate years. Prerequisite: 84-523 and 84-524 or equivalent.

84-538 BIOCHEMICAL MECHANISMS II (3,0) 3

Selected biochemical reactions will be presented from the point of view of organic reaction mechanisms. Kinetics, coenzyme and enzyme catalysis and mechanisms of oxidative phosphorylation will be emphasized. Offered in the Spring. Prerequisite: 84-422 and 84-523, or permission of instructor.

84-532 MODERN INORGANIC CHEMISTRY I (3,0) 3

A theoretical treatment of atomic structure and chemical bonds. Included are such topics as Russell Saunders' coupling, Molecular Orbital Theory, ligand field theory, and descriptive coordination chemistry. Prerequisite: one year of physical chemistry. Kowalak.

84-535 ADVANCED TOPICS IN PHYSICAL CHEMISTRY I (3,0) 3

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor. Prerequisite: permission of instructor. Staff.

84-536 ADVANCED TOPICS IN PHYSICAL CHEMISTRY II (3,0) 3

Same as 84-535 with different topics. Prerequisite: permission of instructor. Staff.

84-540 CHEMICAL KINETICS II (3,0) 3

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanisms, collision theory, and absolute rate theory. Prerequisite: 84-333 or equivalent. Staff.

84-544 CHEMICAL APPLICATION OF GROUP THEORY II (3,0) 3

Classification of molecules into point groups. Properties of groups as applied to chemical systems. Development of the ligand field theory and prediction of electronic and vibrational-rotational spectra. Prerequisite: 84-334, 84-543 or equivalent. Kowalak.

84-561 ADVANCED ORGANIC SYNTHESIS I (3,0) 3

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids, antibiotics. Theoretical implications of organic reactions are also discussed. Offered in alternate years. Prerequisite: 84-524 or equivalent. Staff.

84-563 CHEMISTRY OF NATURAL PRODUCTS I (3,0) 3

This course will cover the proof of structure of various types of natural products, approaches to the total synthesis of these products and also the biosynthetic pathways. Offered in alternate years. Prerequisites: 84-524 — 84-568 or equivalent. Staff.

84-564 ORGANIC QUALITATIVE ANALYSIS II (1,6) 3

Similar to 84-342 but designed for graduate students majoring in chemistry. Prerequisite: 84-222 or equivalent. Scattergood.

84-565 HETEROCYCLIC CHEMISTRY I (3,0) 3

Classification, nomenclature, structure, synthesis and utility of the more important classes of heterocyclic compounds. Offered in alternate years. Prerequisite:84-524 or equivalent. Watterson.

84-568 STRUCTURAL ANALYSIS II (3,0) 3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra-violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy. Open to undergraduate and graduate students. Prerequisite: 84-222 or equivalent. Watterson, Isaks.

Polymer Chemistry (Course Prefix 97)

Primarily for Graduate Students

97-503 POLYMER SCIENCE I I (3,0) 3

Introduction to chain statistics and thermodynamics of macromolecular solution, methods of study of molecular weight and chain conformations, and the properties of polymers in bulk including viscoelasticity and crystallinity. Prerequisite: permission of instructor. A. Blumstein.

97-504 POLYMER SCIENCE II II (3,0) 3

A study of the principles of condensation, free radical, ionic, coordinating and ring-opening polymerization. The topics include the concepts of step-growth and chain-growth polymerization, the effect of polymerization technique on reaction kinetics and molecular weight and molecular weight distribution, and the evaluation of reactivity ratios in copolymerization reactions. Prerequisite: permission of instructor. Salamone.

97-505 POLYMER PREPARATION AND CHARACTERIZATION I I (0,4) 1

An advance laboratory in polymer science concerned with the synthesis and characterization of macromolecules. Prerequisite: permission of instructor. R. Blumstein.

97-506 POLYMER PREPARATION AND CHARACTERIZATION II II (0,4) 1

An advanced laboratory in polymer science concerned with the synthesis and characterization of macromolecules. Prerequisite: permission of instructor. R. Blumstein.

97-511 BIOPOLYMERS I (2,0) 2

Conformation and configuration of vinyl polymers and polypeptides. Helixcoil transitions in proteins and polypeptides. Biological specificity and macromolecular structure. Synthesis of steroregular polypeptides. Structure and physical properties of nucleic acids. Relations of synthetic polymers to naturally occurring polymers. Prerequisite: permission of instructor. Staff.

97-512 BULK PROPERTIES OF POLYMERS II (2,0) 2

Structure and properties of bulk polymers in the glassy, rubbery, and crystalline states. Topics covered include chain statistics, rubber elasticity, crystalline polymers, glass transition, segmental motion and viscoelasticity. Prerequisite: permission of instructor. Staff.

97-549 PHYSICAL CHEMISTRY OF MACROMOLECULES I I (2,0) 2

Physical chemistry of polymers, including structure and conformation, chain statistics, molecular weight distributions and averages, polymerization kinetics and classical and statistical thermodynamics of polymer solutions. Prerequisite: 97-503 or equivalent. Staff.

97-550 PHYSICAL CHEMISTRY OF MACROMOLECULES II II (2,0) 2

Optical and hydrodynamic properties of polymer solutions. Methods of determination of structural parameters, including light scattering, viscometry, and other techniques. Prerequisite: 97-543 or equivalent. Staff.

97-553 ORGANIC CHEMISTRY OF MACROMOLECULES I (2,0) 2

An advanced study in polymer science concerned with the synthesis of macromolecules and their mechanisms of formation. Prerequisites: 97-503, 97-504. Staff.

DEPARTMENT OF EARTH SCIENCES

Environmental Science (Course Prefix 87)

87-101 INTRODUCTION TO ENVIRONMENTAL SCIENCES I (2,0) 1

A survey of environmental problems. Topics considered include air, water and noise pollution, solid and liquid waste disposal, and social, political and economic implications of the problems. Readings, discussions, guest speakers, and field trip will be utilized.

87-102 FOUNDATIONS OF CONSERVATION AND ENVIRONMENTAL CONCERN II (3,0) 3

A study of the evolution of American environmental perception. Topics include an historical review of the changes in federal land policy and the contributions of naturalists, scientists and laymen toward establishing a concern for environmental quality.

87-112 EARTH AND SPACE SCIENCES II (2,2) 3

Topics are selected from astronomy, geology, meteorology, and space science.

87-115 ASTRONOMY I I (3,0) 3

An introduction to the study of astronomy, historical development, instruments, solar system.

87-116 ASTRONOMY II II (3,0) 3

A continuation of 87-115 which is a prerequisite. Special emphasis on stellar systems and stellar evolution.

87-117 ASTRONOMY LAB I I (0,2) 1

Corequisite: 87-115.

87-118 ASTRONOMY LAB II II (0,2) 1

Corequisite: 87-116.

87-201 ENVIRONMENTAL SCIENCE PRACTICUM I I (1,3) 1

Through observation, preparation of materials, and presentation of demonstrations in introductory course laboratories, the student becomes familiar with the materials and teacher-learning situations in environmental science.

87-202 ENVIRONMENTAL SCIENCE PRACTICUM II II (1,3) 1

A continuation of 87-201.

87-232 ATMOSPHERIC SCIENCE II (3,0) 3

A study of the origin and structure of the atmosphere, the physical principles governing atmospheric behavior, fundamental weather patterns, and the behavior and effects of atmospheric pollutants. Prerequisite: one year of physics and chemistry. Corequisite: 87-234.

87-234 ATMOSPHERIC SCIENCE LABORATORY II (0,2) 1

Corequisite: 87-232.

87-354 EARTH AND ENVIRONMENTAL SCIENCE DRAWING TECHNIQUES II (2,3) 3

A course covering the basic pencil and ink drafting procedures in the natural sciences, including major projection techniques, perspective drawings, geologic cross-sections, fence diagrams, and structural geology problems.

87-401 SEMINAR IN ENVIRONMENTAL SCIENCE I I (3,0) 3

Selected topics in environmental science will be explored in depth through laboratory projects, readings, and field work, integrating the principles developed in the various courses of the program and culminating in a report of the work. Prerequisite: senior status in environmental science.

87-455 PHOTOGRAMMETRY AND PHOTO-INTERPRETATION II (3,0) 3

A study of the means and techniques employed in procuring aerial photographs, the geometric relationshsips between ground objects and photo objects for the purpose of extracting accurate and valid measurements, and the science and art of interpreting imaged data on photo planes. Prerequisite: vision from both eyes. Corequisite: 87-457.

87-457 PHOTO-INTERPRETATION LABORATORY II (0,2) 1

Corequisite: 87-455.

87-491 DIRECTED STUDIES IN ENVIRONMENTAL SCIENCE I, II (ARR) 1-3

The student through regular and frequent consultation with his instructor pursues a special problem in environmental science, the results of which are presented in a significant paper. Prerequisite: permission of instructor.

87-496 PRACTICUM EXPERIENCE I, II (ARR) 3

A program of campus and/or off-campus experiences which are developed by the student in consultation with a member of the student's major department. Specific requirements will vary, depending upon departmental policies and the nature of the program undertaken by the student. The intent of the practicum experience is to provide an occasion for applying techniques of problem solving and/or skills which are appropriate to the student's major discipline. May be repeated to a maximum of 9 credits; students will be graded as "satisfactory" or "unsatisfactory". The practicum experience may not be substituted for a required course in the major. Prerequisite: permission of department chairperson.

Geography (Course Prefix 88)

88-101 WORLD AND REGIONAL GEOGRAPHY I (3,0) 3

A survey of the significance, characteristics, and principal geographical problems of the world's major regions.

88-105 INTRODUCTORY PHYSICAL GEOGRAPHY II (3,0) 3

An analysis of processes and spatial distribution of basic physical phenomena with emphasis on regional occurrences and their implication to man. The major topics of concern are: landforms, weather and climate, vegetation and soils.

88-126 GEOGRAPHY OF THE UNITED STATES AND CANADA II (3,0) 3

A regional geography of North America, with emphasis on the human and physical characteristics of different geographic regions and their interaction with each other.

88-141 INTRODUCTION TO WEATHER AND CLIMATE II (2,0) 2

This introductory course is designed to meet two objectives: (1) to provide the interested student with information and knowledge about the atmosphere's dynamic reactions to energy inputs resulting in the spatial distribution of climate around the world. (2) To provide a broad background of the weather elements and climate distributions necessary for further work and study in meterology and climatology. Corequisite: 88-143.

88-143 WEATHER AND CLIMATE LABORATORY II (0,2) 1

Corequisite: 88-141.

Geology (Course Prefix 89)

89-101 GENERAL GEOLOGY I I (3,0) 3

A study of the Earth with emphasis on earth materials, earth structure (crustal and internal) earth history and the development of life. Gives the general student an understanding of the dynamic Earth and provides a foundation for advanced work.

89-102 GENERAL GEOLOGY II II (3,0) 3

A continuation of 89-101, with emphasis on the surface of the Earth and landform development. Includes special topics, introducing the student to recent geological research and applied geological knowledge. Designed for the general and continuing student. Prerequisite: 89-101.

89-103 GENERAL GEOLOGY LABORATORY I (0,2) 1

Corequisite: 89-101.

89-104 GENERAL GEOLOGY LABORATORY II (0,2) 1

Corequisite: 89-102.

89-121 PHYSICAL GEOLOGY I (3,0) 3

An introduction to the physical processes by which the earth undergoes change. Topics include tectonism, petrogenesis, and degradation through various surficial agents. This course should be of primary interest to the science student. Corequisite: 89-123.

89-123 PHYSICAL GEOLOGY LABORATORY I (0,3) 1

Corequisite: 89-121.

89-203 OCEANOGRAPHY I (3,0) 3

A survey of the geologic, chemical, physical and biological aspects of the oceans. Topics include a study of the topography, structure, and origin of ocean basins and their margins, marine sedimentation, chemistry and circulation of ocean waters, and biological environments. Prerequisite: one year of physics and chemistry. Corequisite: 89-205.

89-205 OCEANOGRAPHY LABORATORY I (0,3) 1

Corequisite: 89-203.

89-208 PALENONTOLOGY I (3,0) 3

Nature and origin of fossils: their biology, morphology, paleo-ecology, taxonomy, and evolutionary history. Special emphasis on the rule of fossils in geologic chronology and correlation. Prerequisite: 89-121. Corequisite: 89-210.

89-210 PALENONTOLOGY LABORATORY I (0,2) 1

Corequisite: 89-208.

89-213 ENVIRONMENTAL GEOLOGY I (3,0) 3

Designed to consider how the abundance, occurence and distribution of natural resources and general geologic conditions limit the activites of man. Topics include: the energy gap, natural resource limits on food production and industrial expansion, pollution accompanying resource utilization, urban geology and geologic hazard in land development.

89-251 MINERALOGY I (3,0) 3

An introduction to mineral identification and mineral structure with emphasis on laboratory determination. The course will examine the physical, chemical, and crystallographic properties of minerals. Prerequisite: one semester of chemistry. Corequisite: 89-253.

89-253 MINERALOGY LABORATORY I (0,2)

Corequisite: 89-251.

89-301 OPTICAL MINERALOGY II (3,0) 3

A systematic treatment of the optical properties of minerals. Use is made of crystallographic theory and optical indicatrix representations to identify minerals with the polarizing microscope and X-ray defractometer. Laboratory emphasizes oil immersion techniques, thin section identification with an introduction to spindle stage and X-ray methods. Prerequisite: 89-251. Corequisite: 89-303.

89-303 OPTICAL MINERALOGY LABORATORY II(0,2) 1

Corequisite: 89-301.

89-304 IGNEOUS AND METAMORPHIC PETROLOGY I (3,0) 3

Composition, classification, and origin of igneous and metamorphic rocks. Emphasis will be on thin section identification and use of rock textures and compositions as guides to petrogenesis. Prerequisites: 89-121 and 89-251.

89-306 IGNEOUS AND METAMORPHIC PETROLOGY LABORATORY I (0,3) 1

Corequisite: 89-304.

89-314 HYDROGEOLOGY II (3,0) 3

A study of the distribution and movement of water on the earth's surface with emphasis on the geologic effects. Topics include: application of statistics to streams, ground-water flow nets, well hydraulics. Prerequisite: Introduction to Calculus.

89-316 GEOMORPHOLOGY II (3,0) 3

A study of the physical and chemical processes at work on the earth's surface which result in the formation and development of surface features. Emphasis is placed on the mechanics of erosion (water, wind, ice, and waves) and the morphology and spatial distribution of the resultant landforms. Prerequisite: 89-121. Corequisite: 89-318.

89-318 GEOMORPHOLOGY LABORATORY II (0,2) 1

Corequisite: 89-316.

89-322 STRUCTURAL GEOLOGY I (3,0) 3

An analysis of crustal deformation through detailed study of geologic structures with emphasis upon the response of geologic materials to stress. Field techniques, tectonic principles, and three-dimensional graphic analysis are employed. Prerequisite: one semester of physics. Corequisite: 89-324.

89-324 STRUCTURAL GEOLOGY LABORATORY I (0,2) 1

Corequisite: 89-322.

89-326 GLACIAL AND PLEISTOCENE GEOLOGY II (3,0) 3

A survey and interpretation of the erosional and depositional effects of glaciation with emphasis on the New England area. Topics include glaciology, glacial geology, and Pleistocene stratigraphy. Prerequisite: 89-316.

89-352 STRATIGRAPHY AND SEDIMENTATION II (3,0) 3

Principles and processes of sedimentation and the resulting stratigraphic and structural units. Laboratory work includes stratigraphic cross-sections, identification and description of sedimentary rocks and structures, determination of mass properties of sediments wth emphasis on mechanical and statistical analysis. Prerequisite: 89-121. Corequisite: 89-354.

89-354 STRATIGRAPHY AND SEDIMENTATION LABORATORY II (0,2) 1

Corequisite: 89-352.

89-431 REGIONAL GEOLOGY II (3,0) 3

A survey of the stratigraphy, geologic structure, and physiography of various areas of the world with emphasis on North America. Discussions on the origin of various geologic provinces and the development of a model for global tectonics. Prerequisite: 89-322, 89-208, 89-352.

89-452 GEOCHEMISTRY II (3,0) 3

Application of chemical principles to geologic problems. Topics include crystal chemistry, phase equilibria, stable isotopes and age dating, oxidation-reduction and pH of natural environments, abundance and distribution of elements in the earth, origin and evolution of igneous, metamorphic, and sedimentary rocks.

Meteorology (Course Prefix 93)

93-211 ELEMENTARY METEOROLOGY I I (3,0) 3

Synoptic and mean spatial variations of pressure, temperature and velocity. Cyclones, anticyclones, fronts waves and jet streams. Elements of atmospheric thermodynamics and hydrodynamics; the equation of state, first law of thermodynamics, hypsometric equation, stability of hydrostatic equilibrium, thermal circulation, geostrophic and gradient motion, thermal wind. Prerequisite: 92-133 Calculus B-II and 96-144 Fundamentals of Physics II.

93-212 ELEMENTARY METEOROLOGY II II (3,0) 3

Atmospheric and solar radiation. Atmospheric heat budget. Distribution and causes of fog, clouds, precipitation, thunderstorms and tornados. Elements of general circulation theory and tropical meteorology. Prequisite: 93-211 Elementary Meteorology I.

93-301 ATMOSPHERIC DYNAMICS I (3,0) 3

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium and its stability.

Convection theory. The equations governing large-scale frictionless motion in the atmosphere. Steady state motion. Prerequisite: 93-211 Elementary Meteorology I.

93-302 ATMOSPHERIC DYNAMICS II I (3,0) 3

Unsteady motion: development of thermal circulatuions: barotropic and baroclinic conditions, circulation, vorticity and divergence; mechanism of pressure change; Sutcliffe development and elements of numerical weather prediction. Prerequisite: 93-301 Atmospheric Dynamics I.

93-308 SYNOPTIC METEOROLOGY I (2,3) 3

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network. Prerequisite: 93-211 Elementary Meteorology I.

93-313 PHYSICAL CLIMATOLOGY II (3,0) 3

Measurements and observations. Statistical methods. Atmospheric processes determining the climate; solar and terrestrial radiation, elevation and thermal properties of surfaces, atmospheric circulations and eddy conduction between the atmosphere and land or sea surfaces, hydrological cycle. Prerequisite: 93-211 Elementary Meteorology II.

93-403 PHYSICAL METEOROLOGY I (3,0) 3

Solar and terrestrail radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; radiative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion. Prerequisite: 93-301 Atmospheric Dynamics I.

93-415 ADVANCED ATMOSPHERIC DYNAMICS II (3,0) 3

Atmospheric discontinuities. Viscosity, turbulence and energy dissipation. Perturbation theory of wave motions. Numerical weather prediction techniques and models. Prerequisite: 93-302 Atmospheric Dynamics II.

93-421 ANALYSIS AND FORECASTING I I (1,6) 3

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting. Prerequisites: 93-302 Atmospheric Dynamics II and 93-308 Synoptic Meteorology.

93-422 ANALYSIS AND FORECASTING II II (1,6) 3

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures. Prerequisite: 93-421 Analysis and Forecasting I.

93-430 ATMOSPHERIC DIFFUSION II (3,0) 3

Study of the meteorological processes that affect the diffusion and removal of atmospheric pollutants: theories of diffusion and their application to the calculation of concentrations; the effects of buildings and topography on atmospheric diffusion; meteorological factors involved in the design and location of stacks. Prerequisite: 92-302 Advanced Calculus.

93-441 RESEARCH PROJECT I, II (0,9) 3

An individual or team research project carried out by qualified seniors under supervision of a faculty member.

DEPARTMENT OF MATHEMATICS

Mathematics (Course Prefix 92)

92-101 MATHEMATICAL ANALYSIS I — I (2,2) 3

Review of algebra: sets, linear and fractional equations, inequalities, functions, graphs, trigonometric functions, quadratic equations, straight lines, circles, parabolas, ellipses, hyperbolas, systems of equations, graphs of trigonometric functions, exponents, logarithms, graphs of logarithmic and exponential functions. Shapiro.

92-102 MATHEMATICAL ANALYSIS II — II (2,2) 3

Differential calculus: limits, continuity, derivatives, delta process, differentials, higher-order derivaties, implicit differentiation, applications of derivatives, partial differentiation, maxima and minima of functions of two variables, application of partial derivatives in business and economics. Prerequisite: 92-101. Shapiro.

92-111 MODERN MATHEMATICS — I, II (3,0) 3

A course designed to cover set theory, number systems, relations, set operations, logic, and order. Copley.

92-113 COLLEGE ALGEBRA — I, II (3,0) 3

A review of the fundamental algebraic concepts plus a selection of topics from; exponential and logarithmic functions, systems of equations, and theory of equations. Andrusaitis.

92-114 COLLEGE GEOMETRY — I, II (3,0) 3

An examination of the fundamental concepts of Euclidean Geometry, with particular attention to its logical and historical origins. Prerequisite: Secondary School Geometry. Staff.

92-115 COLLEGE TRIGONOMETRY — II (3,0) 3

Angles and their measure, the trigonometric functions, solving triangles, law of sines, law of cosines, circular functions and their graphs, trigonometric identifites. Staff.

92-116 FINITE MATHEMATICS — II (3,0) 3

An introduction to logic, set theory, counting problems, and elementary probability. Staff.

92-117 INTRODUCTION TO CALCULUS — I, II (3,0) 3

An introductory course covering the real numbers, analytic geometry, functions, graphing, limits, continuity, and differentiation. Staff.

92-118 CALCULUS I — I, II (3,0) 3

Topics include applications of the derivative, the integral and elementary applications, vectors in the plane, conic sections, and a geometric approach to limits and continuity. Prerequisite: 92-117 or equivalent. Staff.

92-121 INTRODUCTORY MATHEMATICS — I (4,0) 4

A learning laboratory course which covers the algebra and trigonometry necessary for calculus. Staff.

92-122 THEORY OF EQUATIONS II (3,0) 3

An introduction to the theory of equations, including discussions of complex numbers, algebraic equations and their roots, separation of roots, Sturm's Theorem, and approximate evaluation of roots. Staff.

92-131 CALCULUS B-I I, II (4,0) 4

Analytic geometry including lines, circles and other conic sections. Functions, derivatives, and curve sketching with applications. Staff.

92-132 CALCULUS B-II II (4,0) 4

Integration. Trigonometric, exponential, logarithmic, and hyperbolic functions. Parametric equations and polar coordinates. Prerequisite: 92-131. Staff.

92-133 CALCULUS A-I I (4,0) 4

Analytic geometry including lines, circles, and other conic sections. Functions, limits and continuity, derivatives and curve sketching with applications, and integration. Staff.

92-134 CALCULUS A-II II (4,0) 4

Trigonometric, exponential, logarithmic, and hyperbolic functions. Parametric equations, polar coordinates, and methods of integraion with applications. Prerequisite: 92-133. Staff.

92-135 INDIVIDUALIZED CALCULUS I I (4,0) 4

Contents same as 92-133 with the use of computers and laboratory experiments. Students can work in groups and proceed at various paces suitable to their needs. Taylor.

92-136 INDIVIDUALIZED CALCULUS II II (4,0) 4

Applications of integration including volumes, arc length, and areas. Differentiation of trigonometric and exponential functions. Methods of integration including parts, partial fractions and trigonometric substitution. Parametric equations, polar coordinates and hyperbolic functions. Prerequisite: 92-135. Condo.

92-201 MATHEMATICAL ANALYSIS I (3,0) 3

Integral calculus: indefinite integration with applications to business and economics, definite integration with applications to business and economics, special methods of integration, numberical methods of integration, multiple integration and differential equations. Matrix algebra: matrix operations, partitioned matrices, determinant of a matrix, inverse of a matrix, solving simultaneous equations with matrices. Prerequisite: 92-102. Staff.

92-202 CALCULUS II I, II (3,0) 3

Topics include trigonometric functions, exponential and logarithmic functions, parametric equations, polar coordinates, and methods of integration. Prerequisite: 92-118. Land.

92-206 ELEMENTARY STATISTICAL ANALYSIS I, II (3,0) 3

A course designed primarily for the social scientist. Includes graphic presentations, measures of central tendency, variability, correlation, standard scores and the unit normal distribution, hypotheses and statistical inference, and tests of significance. Copley.

92-207 MATHEMATICAL TECHNIQUES OF PHYSICS I I (4,0) 4

Hyperbolic functions, polar coordinates, vectors and parametric equations, solid geometry and vectors, partial differentiation, multiple integrals. For physics majors only. Bodor.

92-208 MATHEMATICAL TECHNIQUES OF PHYSICS II II (4,0) 4

Differential equations: first order, linear and power series solutions. Vector differential calculus, vector fields. The integral theorems of Green, Gauss, and Stokes. For physics majors only. Prerequisite: 92-207. Neuringer.

92-209 INTRODUCTION TO THEORY OF COMPUTER PROGRAMMING I, II (3,0) 3

An introduction to the processing of information by computers. Computer logic, memory, inputs and outputs, timesharing, flowcharing techniques, and programming in the BASIC and/or FORTRAN languages. Gravina.

92-211 FUNDAMENTAL CONCEPTS IN MATHEMATICS I (3,0) 3

The algebra of statements. Quantifiers. Methods of proof and disproof. Mathematical induction. Elementary set theory. Ordered pairs, relations, equivalence relations, and functions. Introduction to the real numbers including bounds, completeness, and density of the rationals. Staff.

92-216 HISTORY OF MATHEMATICS I, II (3,0) 3

An investigation of creative mathematics through the lives of mathematicians from classical times to the present. Staff.

92-218 CALCULUS III I, II (3,0) 3

Topics include indeterminate forms, solid analytic geometry, partial derivatives, and multiple integrals. Prerequisite: 92-202. Staff.

92-219 ELEMENTARY COMPUTER PROGRAMMING I, II (3,0) 3

A continuation of 92-209 including advanced programming techniques in the BASIC and FORTRAN programming languages. Staff.

92-221 LINEAR ALGEBRA II (3,0) 3

Vectors in Euclidean space. Vector spaces and subspaces. Linear independence and bases. Inner product spaces. Linear maps and their matrix representations. Applications in R^n. Prerequisites: 92-211 and 92-231/233. Staff.

92-231 CALCULUS B-III I (4,0) 4

Methods of integration. Indeterminate forms and infinite series. Solid analytic geometry, partial derivatives, and multiple integrals. Prerequisite: 92-132. Staff.

92-232 CALCULUS B-IV II (4,0) 4

The classification and solution of ordinary differential equations of first order and higher. Prerequisite: 92-231. Staff.

92-233 CALCULUS A-III I (3,0) 3

Indeterminate forms and infinite series. Solid analytic geometry, partial derivatives, and multiple integrals. Prerequisite: 92-134. Staff.

92-234 CALCULUS A-IV II (3,0) 3

The classification and solution of ordinary differential equations of the first order and higher. Applications. The Laplace transform. Prerequisite: 92-233. Staff.

92-235 INDIVIDUALIZED CALCULUS III I (3,0) 3

Vector algebra including dot and cross products, equations of lines and planes, partial derivatives, chain rule, implicit functions, and multiple integrals with applications. Prerequisite: 92-136. Condo.

92-236 INDIVIDUALIZED CALCULUS IV II (3,0) 3

First and second order differential equations with applications. Series solutions of ordinary differential equations. The Laplace transform. Prerequisite: 92-235. Condo.

92-242 ELECTRONIC DATA PROCESSING II (,0) 3

A three part course dealing first with a background in electronic data processing, covering topics such as basic hardware configurations, common peripheral devices, internal operation, computer arithmetic and numbering systems, and a survey of common languages. The second phase of the course deals with the business oriented computer language COBOL. The third phase deals with the mathematically oriented computer language FORTRAN. The second and third phases are largely based on student programming of the University's CDC 3100 digital computer in both COBOL and FORTRAN for applications involving user-supplied data and data retrieved from disc storage as well as using disc stored programs. Staff.

92-301 APPLIED MATHEMATICS I I (3,0) 3

Matrices. Vector analysis, review of vector algebra, vector calculus, divergence theorem. Green's theorem and Stokes' theorem. Prerequisite: 92-232 or 92-234. Staff.

92-302 APPLIED MATHEMATICS II II (3,0) 3

Series solutions of ordinary differential equations, Bessel functions, Legendre functions. Ordinary differential equations, boundary value problems, Fourier series and integrals. Partial differential equations of physics and engineering, separation of variables. Prerequisite: 92-232 or 92-234. Staff.

92-304 CALCULUS IV I, II (3,0) 3

Sequences and series including comparison and limit comparison tests, the ratio and integral tests, alternating series and conditional convergence, series of functions, Taylor series, remainder theorems, and differentiation and integration of series. Prerequisite:92-218. Staff.

92-305 INTRODUCTION TO REAL ANALYSIS I I (3,0) 3

Equivalence and countability. Sets and sequences of real numbers. Metric spaces. Prerequisites: 92-211 and 92-232/234. Grossman.

92-306 INTRODUCTION TO REAL ANALYSIS II II (3,0) 3

Limits and continuity in metric spaces. The Riemann integral. Derivatives. Prerequisite: 92-305. Grossman.

92-311 APPLICATIONS OF LINEAR ALGEBRA I (3,0) 3

Determinants. Eigenvalues and eigenvectors. Hamilton-Cayley theorem. Spectral theorem and matrix canonical forms. Applications include differential equations, bilinear forms, Fourier series, Markov processes. Prerequisite: 92-221. Berkovits.

92-314 DIFFERENTIAL EQUATIONS II (3,0) 3

A course in ordinary differential equations including equations of order one, linear differential equations, nonhomogeneous equations, method of undetermined coefficients, the Laplace transform, systems of equations, electric circuits and networks, existance and uniqueness of solutions, and nonlinear equations. Prerequisite: 92-304. Staff.

92-315 COMPLEX VARIABLES FOR ENGINEERS I (3,0) 3

Comples variables with emphasis on electrical engineering applications. Analytic functions, Cauchy-Riemann conditions. Line integrals, Cauchy's integral formula and residues. Singularities. Taylor and Laurent series. Conformal mapping. Prerequisite: 92-232 or 92-234. Staff.

92-334 MODERN GEOMETRY I (3,0) 3

Transformations in the Euclidean plane. Non-Euclidean geometry. Topics in hyperbolic geometry and projective geometry. Prerequisites: 92-211 and 92-232/234. Stevens.

92-335 DIFFERENTIAL GEOMETRY II (3,0) 3

Applications to analysis to the study of space curves and surfaces. Prerequisite: 92-211 and 92-232/234. Staff.

92-361 DIGITAL COMPUTER PROGRAMMING I, II (2,0) 2

Programming principles of the FORTRAN language including input-output, arithmetic control and specification statements, subroutines and advanced techniques. Students will process several problems on the University's computer. Staff.

92-362 NUMERICAL ANALYSIS I, II (3,0) 3

Theory and application of numerical techniques including error analysis, linear and non-linear differential equations, matrices, interpolation, numerical integration and curve fitting. Computer solutions are emphasized. Prerequisites: 92-361 and 92-231/233. Staff.

92-363 INTRODUCTION TO COMPUTING I, II (3,0) 3

Types of computers and their operation. Characteristics, storage, and calculation principles. Addressing schemes. Computer arithmetic and logic, numbering systems, instruction codes, input-output organization and devices, organizing computer files and data comunications. Staff.

92-365 BUSINESS COMPUTER PROGRAMMING I (3,0) 3

Programming principles of COBOL (the Common Business Oriented Language), identification, environment, data, and procedures divisions, introduction to compilation procedures. Students will process several business problems on the University's CDC 3100 computer. Moloney.

92-366 ADVANCED FORTRAN PROGRAMMING II (3,0) 3

Advanced FORTRAN programming techniques employing subroutines, subprograms, flowcharting and documentation. Topics will include random number generation, simulation and file manipulation. Prerequisite: 92-361. Staff.

92-367 ASSEMBLER LANGUAGE PROGRAMMING I I (3,0) 3

Absolute machine language coding and the symbolic programming language, the coding of practice problems on a high-speed digital computer using the basic computer instructions including arithmetic, input-output, logic control operations and data manipulation. Prerequisite: 92-361 or permission of instructor. Hurley.

92-371 NUMBER THEORY II (3,0) 3

Congruences and residue classes, quadratic residues. Diophantine equations, number theoretic functions, distribution of primes. Prerequisite: 92-211. Staff.

92-381 OPERATIONS RESEARCH I I (3,0) 3

The use of decision models in industrial systems. Quantitative approach to the industrial alternative. Fundamentals of probability and statistics, PERT techniques, methods of optimization using calculus, inventory control models and queing models. Prerequisite: 92-132 or 92-134 or 92-102. Baldyga.

92-382 OPERATIONS RESEARCH II II (3,0) 3

A continuation of 92-381. Topics include: linear programming, transportation models, nonlinear programming, dynamic programming, games and strategies, Markov analysis, and simulation techniques. Prerequisite: 92-381. Baldyga.

92-383 INTRODUCTION TO STATISTICS I, II (3,0) 3

Sets and probability laws, random variables, mathematical expectation, measure of central tendency and variance. Study of discrete and continuous probability distribution, sampling theory, tests of hypothesis. Regression and correlation. Staff.

92-385 BIOSTATISTICS II (3,0) 3

The application of statistical techniques to the treatment of biological data. Probability distributions, analysis of variance, regression analysis, correlation, and design of experiments. For biological science majors only. Staff.

92-401 APPLIED MATHEMATICS III I (3,0) 3

Applications of mathematical methods to the solution of problems in the various scientific and engineering disciplines. Prerequisite: 92-302. Staff.

92-407 INTRODUCTION TO PROBABILITY THEORY I (3,0) 3

Probability functions and densities, expectations. Moments of probability distributions. Central limit theorem. Prerequisite: 92-232 or 92-234. Fleming.

92-408 INTRODUCTION TO MATHEMATICAL STATISTICS II (3,0) 3

Sampling, decision theory, estimation, hypothesis testing, regression and correlation. Prerequisite: 92-407. Fleming.

92-409 DEMOGRAPHY I (3,0) 3

The study, the methods, and the materials used in the systematic compilation and analysis of population data. Primary focus is on learning sources of data, definitions, collection techniques, population characteristics and dynamics, summarizing and analyzing data, and methods of estimation and projecting. Prerequisite: 92-383. Staff.

92-411 COMPLEX VARIABLES I I (3,0) 3

Complex numbers. Functions of a complex variable. Mappings. Derivatives. Analytic functions. Elementary functions. Integrals. Laurent series. Residues and poles. Contour integration. Prerequisites: 92-232 or 92-234. McElligott.

92-412 COMPLEX VARIABLES II II (3,0) 3

Transformations. Conformal mappings. Boundary conditions. Application in heat conduction, electrostatic potential, and fluid flow. Gamma and beta functions. Inverse Laplace transform. Riemann surfaces. Prerequisite: 92-411. Staff.

92-413 STATISTICAL SAMPLING II (3,0) 3

This course involves the students in actual surveys. The student and instructor draw up the questionnaires, choose the population, compile the data and analyze the results. Prerequisite: 92-383. Staff.

92-414 MATHEMATICAL METHODS IN ENGINEERING MANAGEMENT II (3,0) 3

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy. Staff.

92-416 COMPOUND INTEREST & ANNUITIES—CERTAIN I (3,0) 3

Basic conceptions and definitions of various types of annuities, valuation of annuities—certain, valuation of securites and sinking funds, determination of yields, and construction of tables. Prerequisite: 92-234. Fleming.

92-421 ABSTRACT ALGEBRA I I (3,0) 3

Elementary group theory, groups, cosets, normal subgroups, quotient groups, isomorphisms, homomorphisms, series of groups, the Sylow theorems, free groups and homology groups. Prerequisite: 92-221. Doerr.

92-422 ABSTRACT ALGEBRA II II (3,0) 3

Elementary ring and field theory, quotient rings and ideals, homomorphisms of rings, rings of polynomials, algebraic extensions, automorphisms of fields, separable extensions. Galois Theory. Introduction to categories and functors. Prerequisite: 92-421. Doerr.

92-431 TOPOLOGY I I, II (3,0) 3

Cardinality, partially ordered sets and Zorn's lemma, topology of the line and plane, topological spaces, continuity and topological equivalence. Prerequisite: 92-306. Stevens.

92-432 TOPOLOGY II II (3,0) 3

Metric and normed spaces, compactness, connectedness, product spaces, function spaces, fundamental group. Prerequisite: 92-431. Staff.

92-433 MATRIX THEORY II (3,0) 3

Algebra of vectors, matrices and determinants. Linear transformations and vector spaces. Characteristic values and diagonal forms. Calculus of matrices, matrix polynomials, matrix differential equations. Applications. Prerequisite: 92-232 or 92-234. Staff.

92-442 BOUNDARY VALUE PROBLEMS I (3,0) 3

The Fourier series as a tool of analysis. Orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics and engineering, and boundary value problems. Prerequisite: 92-232 or 92-234. Staff.

92-445 OPERATIONAL CALCULUS II (3,0) 3

The Laplace transform, its properties and uses in translation of a time function, in convolution, in differentiation and in integration. Applications in the analysis of vibrations, deflections, and electric circuits, problems in partial differential equations, and Fourier transforms. Prerequisite: 92-232 or 92-234. Staff.

92-461 SYSTEMS SIMULATION AND MODELING I (3,0) 3

Procedures in model construction and computerized simulation, modeling tools and techniques, model conceptualization and implementation, selected applications of simulation. Prerequisite: 92-361. Staff.

92-462 ADVANCED PROGRAMMING SYSTEMS II (3,0) 3

Basic concepts of assembly programs and compilers, macro-generators, utility programs, supervisors, monitors and high level languages. Prerequisite: 92-367. Staff.

92-463 SYSTEMS DESIGN AND DEVELOPMENT I I (3,0) 3

A general study of the design and development of computer oriented data processing systems including: the approach, requirements of the system, developing the solution, data controls, system controls, system evaluation, and reporting to management. Prerequisite: 92-367. Staff.

92-464 SYSTEMS DESIGN AND DEVELOPMENT II II (3,0) 3

A continuation of 92-463 including: finalizing and implementing the system, post-installation evaluation, inter-departmental coordination and case studies. Staff.

92-465 MANAGEMENT INFORMATION SYSTEMS I I (3,0) 3

Analysis and evaluation of third generation integrated software systems including hardware for requirements, routine and demand reports, architectural evaluation for integrated business function control and the data base design. Staff.

92-466 MANAGEMENT INFORMATION SYSTEMS II II (3,0) 3

Automated decision-making models, systems user consideration, the economics of MIS, detailed case studies of large scale MIS including effects on management organization, personnel and data management. Staff.

92-468 MINICOMPUTER PRINCIPLES AND APPLICATIONS II (3,0) 3

Current minicomputer practices covering both hardware and software including basic minicomputer instruction sets, operating systems, assembler and I/O programming, utilities, interrupts, and interfaces. Scientific, industrial and business applications throughout. Prerequisite: 92-367. Staff.

92-469 COMPLIER CONSTRUCTION TECHNIQUES I (3,0) 3

Typical compiler organization is studied including symbol tables, various types of scans, object code generation, error diagnostics, and optimization techniques. Segments of a classroom compiler are written by students. Prerequisite: 92-367. Staff.

92-470 REMOTE COMPUTING II (3,0) 3

Analysis and use of remote computing systems including time-sharing, remote-batch, and real-time systems. Design characteristics, applications, date communications, economics and management of such systems. Prerequisite: 92-367. Staff.

92-475 MATHEMATICAL LOGIC I (3,0) 3

Propositional and statement logic. A rigorous development of the science of deductive logic with an emphasis on the nature of the logical structure underlying mathematical systems. Prerequisite: 92-211. Staff.

Directed Studies (92-491—493)

Directed studies courses are available only to mathematics majors and may be elected provided that (1) the material to be covered is not available in any other mathematics course, (2) instructors are willing to undertake a directed studies, and (3) no more than 9 credits in mathematics are acquired through directed studies courses.

92-491 DIRECTED STUDIES IN ANALYSIS I, II (3,0) 3

Individual study for the student desiring more advanced or more specialized work in analysis. May be repeated for a total of 6 semester credits. Course may not be substituted for scheduled offerings. Prerequisite: permission of department chairperson. Staff.

92-492 DIRECTED STUDIES IN ALGEBRA I, II (3,0) 3

Individual study for the student desiring more advanced or more specialized work in algebra. May be repeated for a total of 6 semester credits. Course may not be substitued for scheduled offerings. Prerequisite: permission of department chairperson. Staff.

92-493 DIRECTED STUDIES IN GEOMETRY I, II (3,0) 3

Individual study for the student desiring more advanced or more specialized work in geometry. May be repeated for a total of 6 semester credits. Course may not be substituted for scheduled offerings. Prerequisite: permission of department chairperson. Staff.

92-494 TUTORIAL IN MATH I I, II (3,0) 3

Students are involved in aiding the mathematics instruction of the department by participating in tutoring activities. Mathematics majors may not take this course as a mathematics elective. Prerequisite: permission of department chairperson. Staff.

92-495 TUTORIAL IN MATH II II (3,0) 3

Students are involved in aiding the mathematics instruction of the department by participating in tutoring activities. Mathematics majors may not take this course as a mathematics elective. Prerequisite: permission of department chairperson. Staff.

92-496 PRACTICUM EXPERIENCE FOR MATHEMATICS MAJORS I, II (3,0) 3

A program of campus and/or off-campus experiences which are developed by the student in consultation with a member of the mathematics department. Specific requirements will vary, depending upon the nature of the program undertaken by the student. The intent of the practicum experience is to provide an occasion for investigation of a community, social, or cultural area and for application of mathematical skills. (An example of such an activity is tutoring in the Lowell Upward Bound Program.) This course may not be used as a mathematics elective and may be repeated for a maximum of 6 credit hours. Prerequisite: permission of department chairperson. Staff.

92-497 FOUNDATIONS OF MATHEMATICS I (3,0) 3

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics. Prerequisite: permission of department chairperson and senior standing. Staff.

92-498 MATHEMATICS SEMINAR I, II (3,0) 3

Student reading, writing, and criticism of topics from current literature. Review of some important elements of undergraduate work. Prerequisite: permission of department chairperson. Staff.

Primarily for Graduate Students

92-501, 502 REAL ANALYSIS I (3,0) 3; II (3,0) 3

Real and complex number systems. Set theory. Bolzano-Weierstrass and Heine-Borel theorems. Sequences and series. Continuity. Differentiation. Riemann integration. Sequences and series of functions. Functions of several variables. Kaplan.

92-503, 504 FUNCTIONAL ANALYSIS I (3,0) 3; II (3,0) 3

Vector spaces, metric spaces, operators in metric spaces, normed spaces. Hilbert spaces. Linear operators, linear functionals, adjoint and self-adjoint operators in Hilbert space. Approximate solutions of functional equations. Partially ordered normed spaces. Staff.

92-507 REAL VARIABLES THEORY I (3,0) 3

Real valued functions. Continuity, semi-continuity, bounded variation, absolute continuity, differentiability, integrability. Lebesque measure and integration theory. Staff.

92-511, 512 COMPLEX ANALYSIS I (3,0) 3; II (3,0) 3

Complex numbers, analytic functions. Cauchy integral theorem. Cauchy integral formula. Power series. Residues. Applications. Entire functions. Picard's theorems. Riemann mapping theorem. analytic continuation. Riemann mainfolds. Weierstrass monodromy theorem, Weierstrass factor theorem, and Mittag-Leffler theorem. Williams.

92-521, 522 ALGEBRAIC STRUCTURES I (3,0) 3; II (3,0) 3

Properties of rings, groups, and modules in the framework of categorical algebra. Divisibility theory in integral domains. Linear and multilinear algebra. Field extensions and Galois theory. Homology groups. Doerr.

92-531 ALGEBRAIC TOPOLOGY II (3,0) 3

The fundamental group, covering spaces and polyhedra. Singular homology, universal coefficient theorem. Homology and cohomology operations. Homotopy theory.

92-535 HIGHER GEOMETRY II (3,0) 3

Algebraic geometry, transformation groups and invariants, projective transformation, involutions, polarities, conics, non-Euclidian geometries. Staff.

92-537 TENSOR ANALYSIS I I (3,0) 3

Tensor algebra in affine coordinates in n-dimensional space, algebra and calculus of covariant and contravariant tensors and tensor densities, covariant differentiation and parallel displacement, curvature tensors. Prerequisite: permission of instructor. Staff.

92-538 TENSOR ANALYSIS II II (3,0) 3

Applications of tensor analysis to differential geometry of Riemannian spaces, analytical dynamics, mechanics of continuous media and theory of relativity. Prerequisite: permission of instructor. Staff.

92-543 ORDINARY DIFFERENTIAL EQUATION I I (3,0) 3

Existence and uniqueness theorems. Linear systems. Asymptotic behavior. Oscillation and comparison theorems. Plane autonomous systems. Non-linear systems. Prerequisite: 92-302. Neuringer.

92-544 ORDINARY DIFFERENTIAL EQUATIONS II II (3,0) 3

Stability theory and perturbation theory. Topics in optimal control theory. Other topics of current interest. Prerequisite: 92-543. Staff.

92-545 PARTIAL DIFFERENTIAL EQUATIONS I I (3,0) 3

First and second order partial differential equations, transformation theory in the plane and space. Applications to mathematical physics. Prerequisite: 92-302. Spiegel.

92-546 PARTIAL DIFFERENTIAL EQUATIONS II II (3,0) 3

Classification and methods of solution. Properties of solutions of equations with initial and boundary conditions. Existence and uniqueness theorems. Prerequisite: 92-545. Spiegel.

92-547 INTEGRAL EQUATIONS I (3,0) 3

Exact, iterative, and numerical techniques for the solution of linear Volterra and Fredholm integral equations, theorems for general operators. Symmetric kernels, orthogonal system of functions, and the Hilbert-Schmidt theorem. Relation of integral equations to differential equations, applications of the Rayleigh-Ritz, Galerkin, and variation-iteration techniques to the solutions of eigenvalue-eigenfunction problems occuring in mathematical physics and engineering. Prerequisite: 92-302 or permission of instructor. Staff.

92-551 CALCULUS OF VARIATIONS I (3,0) 3

The first variational problem: necessary conditions. Euler's equation. Generalization to several dependent and independent variables. Constraints and Lagrange multipliers. Applications to dynamics and elasticity. Hamilton equations. Sturm-Liouville problems, direct methods, Rayleigh-Ritz method. Prerequisite: 92-302 or permission of instructor. Staff.

92-561 APPROXIMATION THEORY I (3,0) 3

Approximation techniques for functions. Interpolation, rational approximation, orthogonal functions. Staff.

92-563 ADVANCED NUMERICAL ANALYSIS I I (3,0) 3

Solutions of algebraic equations. Interpolation, differentiation, and integration. Least squares and orthogonal polynomials. Ill-conditioning. Linear equations. Eigenvalues. Ordinary and partial differential equations. Spiegel.

92-564 ADVANCED NUMERICAL ANALYSIS II II (3,0) 3

Continuation of 92-563. Prerequisite: 92-563. Staff.

92-571, 572 OPTIMIZATION AND MATHEMATICAL PROGRAMMING I (3,0) 3; II (3,0) 3

Linear programming, simplex methods, dual problem, transportation problem assignment problem, sensitivity analysis, introductory integer programming and applications of each of the techniques. Second semester covers integer programming, network flows and analysis, classical nonlinear optimization, Lagrange multipliers, Kuhn-Tucker conditions, nonlinear programming and some calculus of variations. Costello.

92-584 ANALYSIS OF RANDOM PROCESSES II (3,0) 3

Axiomatic definition of probability. Combined experiments. Bernoulli asymptotic theorems. Bayes theorem. Discrete and continuous random variables. Functions of several random variables. Continuous probability density functions. Expected value, moments, characteristic functions, estimation. Sequences of continuous random variables. Law of large numbers. Staff.

92-585 STOCHASTIC PROCESSES I (3,0) 3

Definition of stochastic processes. Expected values and generating functions. Convergence, contituity, differentiability, and integration of random functions. Stationary processes and ergodic theorems. Theory of recurrent events. Markov chains and processes. Brownian motions. Staff.

92-587, 588 PROBABILITY THEORY AND STOCHASTIC PROCESSES I (3,0) 3; II (3,0)3

Develops probability theory from the Kolmogorov axioms. Analysis of discrete and continuous random variables. Joint density and joint distributions, changes of variables, expectations, variance and higher moments. Laws of large numbers and central limit theorem. Decision theory and prediction theory. Sequences of random variables and stochastic processes. Bernoulli, Poisson, and normal processes. Stationary and independent increments. Markov processes and queueing theory. Estimation theory. Mr. Costello.

DEPARTMENT OF PHYSICS AND APPLIED PHYSICS

Applied Physics (Course Prefix 80)

80-111 THE PHYSICAL ENVIRONMENT I I (3,0) 3

A physical science course for students with majors outside the College of Pure and Applied Science. Topics involve the physical aspects of man's interaction with his terrestrial environment and include energy, traffic, noise, and safety. Carr.

80-112 THE PHYSICAL ENVIRONMENT II II (3,0) 3

A physical science course for students with majors outside the College of Pure and Applied Science. Topics deal with the application of physical principles to the atmosphere, the solar system, space travel, and the stars. Carr.

80-161 COMPUTATIONAL TECHNIQUES FOR PHYSICAL SCIENCES I I (2,0) 2

This course is designed to introduce freshmen students to computational techniques in the physical sciences using digital computers. Mathur.

80-162 COMPUTATIONAL TECHNIQUES FOR PHYSICAL SCIENCES II II (2,0) 2

More advanced computational techniques in the physical sciences using digital computers. Prerequisite: 80-161 or equivalent. Mathur.

80-201 PHYSICS OF RADIATION I (3,0) 3

Relativistic kinematics, the photon, Compton effect, masses and charges of ions, atomic structure, X-rays, matter waves, uncertainty principle. Prerequisite: 95-144. Corequisite: 95-245. Egan, Couchell.

80-202 PHYSICS OF NUCLEI II (3,0) 3

An introduction to nuclear particles, nuclear forces, nuclear structure and systematics, nuclear reactions, nuclear radiations and their interactions with matter. Prerequisite: 80-201. Egan, Couchell.

80-206 NUCLEAR INSTRUMENTATION I II (2,4) 4

Lecture: Fundamentals of electronic circuits and devices as applied to digital and analog circuits encountered in instrumentation systems. Laboratory: basic measurement techniques; use of the oscilloscope; characteristics of transistors, diodes, and integrated circuits; transistor amplifiers, feed-back and operational amplifiers; digital circuits, simple logic. Prerequisites: 95-243 or 95-245. Smith.

80-301 LABORATORY PRACTICUM IN PHYSICS I I (1,3) 1

A course for students preparing to teach physics at any level. Through observation, preparation of materials, and presentation of demonstrations in introductory course laboratories, the student becomes familiar with the materials and the teaching-learning situation in physical science. Prerequisite: junior status as a major in physics or applied physics. Carr.

80-302 LABORATORY PRACTICUM IN PHYSIC II II (1,3) 1

A continuation of 80-301. Prerequisite: junior status as a major in physics or in applied physics. Carr.

80-305 NUCLEAR INSTRUMENTATION II I (2,4) 4

An integrated laboratory and lecture course covering the operating principles and applications of nuclear radiation detectors, associated electronic signal processing equipment, and data analysis techniques. Topics covered include charged-particle, photon and neutron detection, as well as charged-particle and gamma-ray spectroscopy. The laboratory involves the use of scintillators, photomultiplier tubes, solid state detectors, gas-filled counter, a variety of electronic instrumentation including oscilloscopes and experiments utilizing the Pinansky Nuclear Center's 1 MW nuclear reactor. Prerequisites: 80-202, 80-206. Egan, Mittler.

80-306 NUCLEAR INSTRUMENTATION III II (1,2) 2

An integrated laboratory and lecture course involving "state of art" nuclear spectroscopy techniques. Gamma-ray spectroscopy utilizing GE (Li) detectors and multi-channel analyzers for isotope identification and absolute gamma activity measurements is emphasized. Other experiments include neutron time-of-flight spectroscopy utilizing the Pinansky Nuclear Center's 5.5 MV Van de Graaff generator. A student who has completed this course will have acquired the ability to set up a complete research quality gamma-ray spectroscopy system and will be able to analyze the data obtained with such a system. Prerequisite: 80-305. Egan, Mittler.

80-311 APPLIED MECHANICS I (4,0) 4

Forces and moments. Equilibrium of rigid and deformable bodies. Particle kinematics. Dynamics of particles and rigid bodies. Work, energy, and momentum. Friction. Mechanical oscillations. Elastic properties and strength of materials. Fluid statics and dynamics. Prerequisite: 95-144, 92-208. Staff.

80-335 APPLIED MODERN PHYSICS I I (3,0) 3

Introductory treatment of modern physics and its applications. Relativity. Quantum mechanics. Atoms and molecules. Kinetic theory and statistical mechanics. Plasma and magnetohydrodynamics. Lasers and applications. Prerequisites: 95-246, 92-208. Staff.

80-336 APPLIED MODERN PHYSICS II II (3,0) 3

Continuation of 80-335. Elements of solid state physics. Crystal structure. Lattice vibrations. Band theory. Semiconductors and applications. Magnetism and applications. Superconductivity. Elements of nuclear physics. Radioactivity. Accelerators. Reactors. Fission. Fusion. Prerequisite: 80-335. Staff.

80-342 ENERGY AND ENVIRONMENT I, II (3,0) 3

A study of the principles of energy production from fossil fuels and from nuclear, solar, geothermal, and other sources. An analysis of the environmental and economic factors will be included. Prerequisite: 95-101 or the completion of a 2-semester or a 3-semester sequence in introductory physics. Carr.

80-354 APPLIED ELECTROMAGNETISM II (4,0) 4

Charges, fields, and potentials. Dielectric materials and applications; piezoelectrics. Magnetic field. Magnetic materials and applications; ferrites. Induced emf and inductance. Conductors. Maxwell equations and wave propagation. Prerequisites: 92-208, 95-245. Staff.

80-381 PHYSICAL ACOUSTICS I, II (3,0) 3

Oscillations. Vibrations and strings. Plane sound waves. Spherical waves and radiation. Sound sources. Sound detectors. Sound recording. Speech, hearing noise, and communication. Acoustics in architecture. Acoustic measurements and instruments. Ultrasonics. Underwater sound. Prerequisites: 92-208, 95-144. Staff.

80-397 COMPUTER PROGRAMMING AND APPLICATIONS I I (3,0) 3

Overview on the use of modern digital computers. Principles of FORTRAN-4 including flowcharts, arithmetic, relational, and specification statements, DO-loops, functions, and subroutines. application of computer techniques to solve physical problems ex. analysis of experimental data, Monte Carlo techniques. About 10 programs to be written and run on the Univ. computer system. Mittler.

80-398 COMPUTER PROGRAMMING AND APPLICATIONS II II (3,0) 3

Continuation of 80-397. Advanced topics in FORTRAN-4 including double precision, complex numbers, and roundoff. Use of library routines and mass storage devices. Advanced techniques in experimental data analysis and simulation problems. Mittler.

80-437 APPLIED OPTICS I I (3,0) 3

Topics in applied optics including geometrical optics, optical design, aberration, lens design, radiametry, photometry, interferometry, optical testing and evaluation techniques. Kuppenheimer.

80-438 APPLIED OPTICS II II (3,0) 3

Continuation of 80-437. Kuppenheimer.

80-441 APPLIED QUANTUM MECHANICS I, II (3,0) 3

A medium-level treatment of quantum mechanics in a form designed for applications. Wave and matrix mechanics. Symmetry and group theory. Perturbation methods. Collision. Quantization of radiation. Applications chosen from atomic, laser, and solid state physics. Other applications may also be considered depending on the interest of the students. Prior familiarity with elementary quantum concepts is assumed. Prerequisite: permission of instructor. Staff.

80-445 X-RAY DIFFRACTION AND CRYSTAL STRUCTURE I, II (2,3) 3

Elementary crystal structure. Generation and production of X-rays. Diffraction of X-rays by crystals. Elementary theory of scattering from electrons and atoms. Analytical methods: Laue patterns, rotation and oscillation patterns, powder patterns. Cameras and diffractometers. Applications to metallurgical and solid state problems. Lectures will be supplemented by laboratory work. Open to students from other departments, by permission of the instructor. Staff.

80-447 LASERS AND MASERS I, II (3,0) 3

Introductory treatment of lasers, masers, and their applications: interaction of radiation with matter including electric and magnetic dipole transitions. The concept of stimulated emission. Rate equations. Optical resonators. Collision and line broadening processes. Study of various gaseous and solid state lasers and masers. Applications to harmonic generation, holography, and optical modulation techniques. Prerequisite: 80-335 or equivalent. Waldman.

80-455 PLASMA PHYSICS I, II (3,0) 3

An introduction to the field of plasma physics and its applications. Hydrodynamic equations. The Boltzmann equation. Motion of charged particles in electric and magnetic fields. Propagation of electromagnetic waves in plasma. Collision and radiation processes. Longitudinal oscillations of electrons and ions. Transport processes. Instabilities. Topics from solid state plasmas. Applications. Corequisites: 80-354, 95-421. Staff.

80-457 PHYSICAL ELECTRONICS I, II (3,0) 3

Elements of quantum mechanics. Statistics. Electron emission from solids Vacuum devices and gaseous processes. Semiconductors and their devices; diodes and transistors. Electron beams;

the klystron. Modern amplifiers; the maser, the laser, and magnetotron. Noise. Corequisite: 80-335. Staff.

80-499 COMPUTER METHODS AND NUMERICAL ANALYSIS I (3,0) 3

Computer methods in the solution of engineering and physics problems using numerical analysis techniques. Topics include: error analysis, solution of algebraic, transcendental and polynomial equations, quadrature formulas for numerical integration, systems of linear equations, matrix manipulation, interpolation techniques, numerical differentiation, solution of differential equations, and curve fitting using linear and nonlinear least square methods. Mathur.

Primarily for Graduate Students

80-586 SEMICONDUCTORS I, II (3,0) 3

Transport and optical properties of semiconductors. Statistics, collision mechanisms, and band structure. Hot electrons. High magnetic field phenomenon. Devices; junctions and transistors; Gunn oscillators; semi-conductor lasers. Prerequisite: permission of instructor. Staff.

Physics — Lecture Courses (Course Prefix 95)

95-103 GENERAL PHYSICS I I (3,0) 3

The first semester of a year course which surveys the field of physics for students with major outside the College of Pure and Applied Science. Topics include force and motion, vectors, gravity, energy and momentum, heat and thermodynamics, and oscillations. Corequisite: 96-103. Staff.

95-104 GENERAL PHYSICS II II (3,0) 3

A continuation of General Physics I. Topics include waves, light, sound, electricity, magnetism, the atom, and the nucleus. Prerequisite: 95-103. Corequisite: 96-104. Staff.

95-141 INTRODUCTORY PHYSICS I, II (3,0) 3

Units, vectors, statics, rotational statics, motion with constant acceleration, Newton's 2nd law, gravity and motion in a plane. Corequisite: 96-141. Wilner, Karakashian, and Staff.

95-142 CONCEPTS OF PHYSICS I II (3,0) 3

Collisions, impulse, momentum, rotational motion, torque, angular momentum, simple harmonic motion; waves, standing waves. Doppler effect; geometrical optics, interference, diffraction; temperature, thermometers, ideal gas, heat, heat capacity, change of state, first and second laws of thermodynamics. Prerequisites: 95-141, 92-131 or 92-133. Corequisite: 96-144. Marcella.

95-144 FUNDAMENTALS OF PHYSICS I II (4,0) 3

Work, energy, power, collisions, impulses, momentum, rotational motion, torque, angular momentum, simple harmonic motion; waves, standing waves, Doppler effect; geometrical optics, interference, diffraction; temperature, thermometers, ideal gas, heat, heat capacity, change of state, first and second laws of thermodynamics. Prerequisites: 95-141, 92-131 or 92-133. Corequisite: 96-144. Wilner, Karakashian, and Staff.

95-147 HONORS PHYSICS I I (4,0) 4

Introductory physics at a more challenging level, commencing with elementary mechanics: fundamental units and dimensions; vector treatment of forces and velocities; statics; equilibrium; kinematics of uniform and accelerated linear motion in one and two dimensions; Newton's laws of motion; friction; relativistic motion and frames of reference; dynamics — impulse, momentum, work, energy and power, conservation and invariance principles; motion of interacting systems; rotational motion — kinematics and dynamics; rotational angular momentum and energy; radial and tangential forces and acceleration; motion of gyroscopes and planets, laws of planetary motion. Corequisite: 96-147. Kannenberg.

95-148 HONORS PHYSICS II II (4,0) 4

Gravitation; elasticity; fluid mechanics; simple harmonic motion; wave motion. Temperature and heat; ideal gas behavior; kinetic theory; thermal properties of matter, thermodynamics and statistical mechanics; radiation and quantum concepts. Prerequisites: 95-147, 96-147 and 92-133. Corequisite: 96-148. Kannenberg.

95-149 SURVEY OF PHYSICS I (3,0) 3

An introduction to the topics of physics including: forces, work and energy, motion, conservation laws, electricity, magnetism and waves. For business majors only. Altman, Miller.

95-151 ELEMENTS OF PHYSICS II (3,0) 3

An introduction of the topics of physics including: force, work and energy, motion, conservation laws, electricity, magnetism and waves. For industrial technology majors only. Corequisite: 96-151. Hardy.

95-201 PRINCIPLES OF PHYSICS I I (3,0) 3

An introduction to physics for students with majors other than physics in the College of Pure and Applied Science. Topics include Newtonian and relativistic mechanics in one and two dimensions, harmonic oscillators and waves, calorimetry, heat transfer, and thermodynamics. Prerequisite: 1 year of college mathematics. Corequisite: 96-201. Carr, Worrell.

95-202 PRINCIPLES OF PHYSICS II II (3,0) 3

A continuation of Principles of Physics I (q.v.). Topics include geometric and physical optics, electricity and agnetism, and atomic and nuclear physics. Prerequisite: 95-201. Corequisite: 96-202. Carr, Worrell.

95-209 ELECTRICITY AND MAGNETISM I (4,0) 4

Electrostatics: electric charge, Coulomb's law, electric field, Gauss' law, electric potential, capacitance, and dielectrics; electrodynamics: electric current, resistance, Ohm's law, resistivity, electromotive force, d-c circuits, magnetic field, magnetic dipole moment, Biot-Savart law, Ampere's law, Faraday's law, inductance, and Maxwell's equation. Prerequisite: 95-144 or 95-148. Couchell, Kegel.

95-210 INTRODUCTORY MODERN PHYSICS II (4,0) 4

Special theory of relativity: Galilean transformation, nature and propagation of light, Einstein's postulates and assumptions, Lorentz transformation, simultaneity, time dilation, space contraction, velocity transformation, four vectors, proper time, Newton's second law of motion, conservation laws, center of mass, and collision problems. The electron: Millikan's experiment. Quantum nature of light: the Compton effect and the photoelectric effect. Matter waves: Davisson-Germer experiment. Wave-particle duality and the Uncertainty Principle. Prerequisite: 95-209. Kegel, Couchell.

95-218 PHYSICS OF SOUND AND MUSIC I, II (3,0) 3

A course designed for students with majors in the College of Music or in other colleges outside the College of Pure and Applied Science. Strings, woodwinds, and brasses are examined in terms of the principles of physics. The basic principles are presented in a relatively non-mathematical manner, and extensive use of demonstrations is made to aid in understanding the concepts. Fundamental concepts such as displacement, time, velocity, acceleration, force, energy, resonance, and waves are presented and related to the various instruments. Wave shapes and spectral energy distributions are examined for representative instruments. The acoustic properties of the ear and of rooms are also discussed. Ring.

95-238 OPTICS AND WAVES II (2,0) 2

Waves: general representation, superposition, interference, standing waves, beats, and Doppler effect; acoustic waves; optics: nature of light, law of reflection, law of refraction, Huyghens' principle, mirrors, thin lenses, interference, Fraunhofer diffraction, multiple slits, diffraction grating, polarization, speed of light, electromagnetic waves. Prerequisite: 95-209. Wong.

95-243 CONCEPTS OF PHYSICS II I (3,0) 2

Electric charge, Coulomb's law, electric field, electric potential; D.C. current, Ohm's law, Joule effect; magnetic effects of charged particles and electric currents, Faraday's law, Lenz's law, examples; quantum theory: photoelectric effect, Compton effect, wave-particle duality, de Broglie waves, Davisson-Germer experiment, Bohr atom, atomic spectra. Prerequisites: 95-142, 92-132 or 92-134. Corequisite: 96-245. Worrell, Ring.

95-245 FUNDAMENTALS OF PHYSICS II I (4,0) 3

Electric charge, Coulomb's law, electric field, Gauss' law, electric potential, capacitance; D.C. current, Ohm's law, Joule effect, electromotive force, Kirchoff's rules, simple D.C. Circuits; magnetic field, current loops, Ampere's law, Faraday's law, electromagnetic induction; quantum theory; photoelectric effect, Compton effect, wave-particle duality, de Broglie waves, Davisson-Germer experiment, Bohr atom, atomic spectra, nuclear structure. Prerequisites: 95-144, 92-132 or 92-134. Corequisite: 96-245. Harihar, Ring, Staff.

95-246 SPECIAL TOPICS IN PHYSICS II (4,0) 4

Special topics from the various branches of classical and modern physics, such as hydrodynamics, acoustics, optics, relativity, quantum mechanics, atomic and molecular physics, nuclear physics, elementary particles, and solid state physics. Prerequisite: 95-245. Corequisite: 96-246. Sebastian.

95-247 HONORS PHYSICS III I (4,0) 4

Elements of electricity and magnetism — electrostatics, Coulomb's law, electric fields, Gauss' law and flux considerations, potential, D.C. circuitry, dielectrics; magnetic fields and effect; magnetic properties of material, A.C. circuitry; electromagnetic theory. Maxwell's equation. Prerequisites: 95-142, 95-144 or 95-148, 92-132. Kegel, Couchell.

95-248 HONORS PHYSICS IV II (4,0) 4

Wave behavior and interference; diffraction; acoustics and optics; polarization; quantum phenomena; theory of atoms and molecules; atomic nuclei; high-energy and particle physics; current developments in pure and applied physics. Prerequisite: 95-247 or equivalent. Kegel, Couchell.

95-283 INTRODUCTION TO THE THEORY OF RELATIVITY I (2,0) 2

Galilean transformation, Lorentz transformation, simultaniety; velocity and acceleration transformations, relativistic energy, four-vectors. Kegel.

95-308 MATHEMATICAL TECHNIQUES OF PHYSICS II (4,0) 4

Complex numbers, elementary functions; analytic functions, line integrals, Cauchy's formulae, residue theorem; partial differential equations of physics: separation of variables, eigenvalue problems, Fourier series, Fourier transforms. Prerequisite: 92-208. Sebastian.

95-313 MECHANICS I (4,0) 4

Kinematics of a single particle, analysis of Newton's laws of motion, mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, the linear oscillator, forced oscillations and resonance, central force motion, kinematics and elastic collisions in two particle systems, mechanics of particles, generalized coordinates, Lagrange's equations, the Hamiltonian function. Prerequisite: 92-208. Stimets.

95-335 INTRODUCTORY QUANTUM MECHANICS I I (3,0) 3

De Broglie waves, the Schroedinger equation, wave functions, wave packets, Heisenberg uncertainty principle, expectation values, particle in a box, the simple harmonic oscillator, free particles, step barrier, barrier penetration, square well potential. Prerequisite: 95-210. Staff.

95-336 INTRODUCTORY QUANTUM MECHANICS II II (3,0) 3

The three dimensional Schroedinger equation, the deuteron nucleus, angular momentum, spin, the hydrogen atom, spin-orbit interaction, Zeeman effect, Pauli exclusion principle, atomic structure, spectroscopic nomenclature, and molecular structure. Prerequisite: 95-335. Staff.

95-353 ELECTROMAGNETISM I I (3,0) 3

The theory of electromagnetic fields using vector analysis and Maxwell's equations: static electric and magnetic fields in conductors and dielectrics, scalar and vector potentials, solutions to Laplace's equation, image charge problems, and energy density problems. Prerequisites: 92-208, 95-210. Cole.

95-354 ELECTROMAGNETISM II II (3,0) 3

Time-varying electromagnetic fields, ferromagnetic materials, propagation of plane waves in conductors and dielectrics, Snell's law, Fresnel equations, polarization, and radiation from accelerated charges and antennas. Prerequisite: 95-353. Cole.

95-385 ASTRONOMY AND ASTROPHYSICS I I (3,0) 3

This course is designed for an interdisciplinary general undergraduate (upperclassmen) audience. Fundamentals of astronomy and astromechanics, introductory survey of astrophysics and the solar system (i.e., planetary astronomy). Sheldon.

95-386 ASTRONOMY AND ASTROPHYSICS II II (3,0) 3

Continuation of 95-385. Sun as a star, stellar and galactic astronomy, and cosmology. Sheldon.

95-400 PHILOSOPHY OF PHYSICS I, II (3,0) 3

A study of essays by 19th and 20th century philosophers of science analyzing the foundations of physical theory. Topics will include an introduction to philosophical analysis, the structure and meaning of a physical theory; focusing upon the theories of classical mechanics, electromagnetism, thermodynamics, relativity and quantum theory. Prerequisites: 95-243 or 95-245. Miller.

95-421 STATISTICAL THERMODYNAMICS I (4,0) 4

An integrated study of thermodynamics and statistical mechanics: review of the experimental foundations and historical development of classical thermodynamics; probability and statistical methods of studying macroscopic systems; atomic basis of the laws of thermodynamics and microscopic definitions of thermodynamics quantities using the method of ensembles; entropy and related quantitied; TdS equations, Maxwell relations, equation of state, and applications; canonical and grand canonical ensembles; phase transitions; quantum statistics; application to radiation, magnetism, specific heats. Prerequisite: 95-336. Sebastian.

95-461 TOPICS IN NUCLEAR PHYSICS I (3,0) 3

This course is designed to familiarize the student with a few research areas in the field of nuclear physics. The topics covered may vary from year to year. They will be chosen from the following list: nuclear constituents, fundamentals of interaction forces, liquid drop model and stability energetics, cross sections, passage of ionizing radiations through matter, alpha-decay, beta-decay and electron capture, gamma-decay and internal conversion, nuclear reaction systematics, fission and fusion, models of nuclear structure, and reaction mechanisms. Prerequisite: 95-336. Sheldon.

95-472 TOPICS IN SOLID STATE PHYSICS II (3,0) 3

Crystal structures, X-ray and neutron diffractions, lattice vibrations, the free electron and the band models of metals, semiconductors and applications, dielectric and optical properties of solids, magnetism, and superconductivity. Prerequisite: 95-421. Barcus.

95-495 SPECIAL RESEARCH PROBLEMS I I (3,0) 3

Special problems in theoretical and experimental physics assigned to the individual student with emphasis on modern research methods and preparation of results for publication. Prerequisite: permission of department chairperson and instructor. Staff.

95-496 SPECIAL RESEARCH PROBLEMS II II(3,0) 3

A continuation of 95-495 for a second semester. Prerequisite: permission of department chairperson and instructor. Staff.

95-497 BIOPHYSICS SEMINAR I I (2,0) 1

A seminar type course with the students leading discussions on almost any topic of physical interest in biology, but with emphasis on the following: the living cell, its structure and function, how it moves, divides and transforms energy, enzymes the structure of proteins and nucleic acids, the DNA and RNA molecules, the gene and the genetic code. Cole.

95-498 BIOPHYSICS SEMINAR II II (2,0) 1

A continuation of 95-497: the mechanism of muscle contraction, the electrical nature of cells, the nerve impulse, biological transducers, the ear, the eye, brain waves, psychophysics, artificial "life", and the origin and evolution of living systems. Cole.

95-499 TOPICS IN THE HISTORY OF 19TH AND 20TH CENTURY PHYSICS I (3,0) 3

The topics discussed will vary from year to year and will include the development of field theories, thermodynamics, quantum theory, the special and general theories of relativity, and nuclear physics. The topic for Fall 1976 is the historicsl is the historical development of Einstein's relativity theory of 1905. Einstein's seminal paper will be analyzed in detail. Review of the electromagnetic theories of Maxwell, Helmholtz, Hertz, and Lorentz; attempts to detect the earth's motion relative to the ether; the theories of the electron of Abraham and Lorentz. The interplay between philosophy and physics will be emphasized. Primary sources will be used, and translations provided whenever necessary. Prerequisite: permission of instructor. Miller.

Primarily for Graduate Students

95-500 SEMINAR IN THE HISTORY OF SCIENCE II (3,0) 3

Topics will vary from year to year. The topic for Spring 1977 will be the study of the effect of the new positivism on science in the late nineteenth and early twentieth centuries. The works of Henri Poincare, Ernest Mach, and Pierre Duhem will be discussed. Prerequisite: permission of instructor. Miller.

95-505, 506 MATHEMATICAL METHODS OF PHYSICS I-II I (4,0) 4: II (4,0) 4

Vector and Cartesian tensor analysis; matrices and determinants; partial differential equations, boundary value problems and special functions. Numerical analysis and applications; theory of analytic functions; Green's functions. Prerequisite: permission of instructor. Karakashian.

95-507 HIGH-ENERGY PHYSICS I, II (3,0) 3

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation of high-energy physics, strong and weak interactions, dispersion relations, Regge poles and unitary symmetry. Prerequisite: 95-516. Sebastian.

95-511 CLASSICAL MECHANICS I (3,0) 3

Lagrangian formulation (including Lagrange Multipliers), the Kepler problem and Rutherford scattering; rotating coordinate systems and rigid body motion; small oscillations and stability problems Hamiltonian formulation. Prerequisite: permission of instructor. Korff.

95-515, 516 QUANTUM MECHANICS I-II I (4,0) 4; II (4,0)4

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory. Prerequisite: 95-511. Kannerberg.

95-517, 518 ADVANCED QUANTUM MATHEMATICS I-II I (3,0) 3; II (3,0) 3

The formal theory of scattering, Klein-Gordon and Dirac equations and simple applications; quantum theory of radiation. Symmetry principles and elements of groups theory; introduction to many-body theory; Hartree-Fock self-consistent calculations and their applications to atomic, solid state, and nuclear physics. Prerequisite: 95-516. Staff.

95-522 STATISTICAL MECHANICS (3,0) 3

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics. Prerequisite: permission of instructor. Sebastian.

95-558, 559 ELECTROMAGNETIC THEORY I-II I (3,0) 3; II (3,0) 3

Electrostatics and magnetostatics with special attention to boundry value problems. Quasistatic fields and displacement currents. Maxwell's equations and conservation laws, the Special Theory of Relativity. Waveguides, simple radiating systems, scattering and diffraction, radiation from an accelerated charge; plasma physics. Prerequisite: permission of instructor. Corequisite: 95-505/506. Couchell.

95-560 APPLIED QUANTUM MECHANICS I, II (3,0) 3

Relativistic Dirac equation of the electron and its simple applications. Symmetry principles in quantum mechanics and elements of group theory. Introduction to many body theory. Hartree-Fock self-consistent calculations, and their applications to the theory of many electron atoms, and the nuclei of atoms. Emission and absorption of radiation by quantum systems such as atoms and nuclei. Widths and intensities of spectral lines. Selection rules. Electric and magnetic multipole moments of nuclei and e.m. transition probabilities for nuclei. Prerequisite: 95-515/516. Sebastian.

95-561, 562 NUCLEAR PHYSICS I-II I (3,0) 3; II (3,0) 3

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics. Prerequisite: permission of instructor. Sheldon.

95-573 ADVANCED THEORY OF SOLIDS I I (3,0) 3

Lattice vibrations and their interactions with X-rays, neutrons and light. The band model of solids and energy band calculations. The Fermi surface. Transport and optical properties in metals and semiconductors. Prerequisite: 95-516 and permission of instructor. Stimets.

95-574 ADVANCED THEORY OF SOLIDS II II (3,0) 3

Magnetism and magnetic resonance. Superconductivity. Many body theory and its applications. Collective excitations. Green function techniques in solid state physics. Prerequisite: 95-573. Stimets.

95-575, 576 NEUTRAL PARTICLE TRANSPORT I-II I (3,0) 3; II (3,0) 3

Boltzmann and integral transport equations. Spherical harmonic and variational methods. Corrections to diffusion theory. Special methods of solving transport equations. Adjoint functions. Applications. Prerequisite: permission of instructor. Beghian.

95-581, 582 THEORY OF NOISE AND RANDOM PROCESSES I-II I (3,0) 3; II (3,0) 3

Probabilities. Statistical analysis of random processes. Ensemble theory. Signals and noise in nonlinear systems. Information theory. Normally distributed random processes. Langevin, Fokker-Planck and Boltzmann equations. Thermal, shot and impulse noise. Linear measurements, prediction, and optimum filtering. A strong background in applied mathematics is required. Some knowledge of AC circuit theory and electronics would also be useful. Prerequisite: 95-505/506. Korff.

95-583, 584 GENERAL THEORY OF RELATIVITY I-II I (3,0) 3; II (3,0) 3

Review of Newtonian gravitational theory and special relativity. The weak and strong principles of equivalence. Tensor analysis in Riemann spaces. Einstein's equations for the gravitational field. Classic tests of Einstein's theory; shperically symmetric solutions. Gravitational field theory and the canonical analysis of general relativity. Prerequisite: knowledge of special relativity including tensor notation. Kannenberg.

Physics — Laboratory Courses (Course Prefix 96)

96-103 GENERAL EXPERIMENTAL PHYSICS I I (1,2) 1

The first semester of a year course which surveys the field of experimental physics for students with majors outside the College of Pure and Applied Science. Corequisite: 95-103. Staff.

96-104 GENERAL EXPERIMENTAL PHYSICS II II (1,2) 1

A continuation of General Experimental Physics I with topics correlated with General Physics II. Prerequisite: 96-103. Corequisite: 95-104. Staff.

94-141 FUNDAMENTALS OF EXPERIMENTAL PHYSICS I I, II (1,2) 1

An introductory course on the methods and techniques of experimental physics. Experiments are selected principally in the areas of statics and kinematics. Corequisite: 95-141. Staff.

96-144 FUNDAMENTALS OF EXPERIMENTAL PHYSICS II II (1,2) 1

A continuation of 96-141 with experiments principally in mechanics, waves, optics and thermodynamics. Prerequisite: 95-141. Corequisite: 95-142 or 95-144. Staff.

96-147 FUNDAMENTALS OF EXPERIMENTAL PHYSICS I HONORS I (1,3) 1

An introductory course at the honors level on the methods and techniques of experimental physics. Lectures on measurement uncertainties and error analysis are included and experments are selected principally in the areas of statics and kinematics. Corequisite: 95-147. Staff.

96-148 FUNDAMENTALS OF EXPERIMENTAL PHYSICS II HONORS II (0,3) 1

A continuation of 96-147 with experiments selected principally from mechanics, waves, optics and thermodynamics. Students are introduced to more advance measurement techniques and instrumentation than in 96-144. Prerequisite: 96-147. Corequisite: 95-148. Staff.

96-151 ELEMENTS OF EXPERIMENTAL PHYSICS II (3,0) 1

This course is for Industrial Technology majors and introduces the student to basic experimental techniques in physics with applications principally in the areas of mechanics and electricity. Corequisite: 95-151. Staff.

96-201 PRINCIPLES OF EXPERIMENTAL PHYSICS I I (1,2) 1

An introduction to experimental physics for students with majors other than physics in the College of Pure and Applied Science. Topics include measurement and error, mechanics, waves, and heat. Corequisite: 95-201. Carr, Worrell.

96-202 PRINCIPLES OF EXPERIMENTAL PHYSICS II II (1,2) 1

A continuation of Principles of Experimental Physics I (q.v.). Topics include optics, electricity and magnetism, spectroscopy, radioactivity, and statistical analysis. Prerequisite: 96-201. Corequisite: 95-202. Carr. Worrell.

96-245 FUNDAMENTALS OF EXPERIMENTAL PHYSICS III I (1,2) 1

Experimental methods and techniques in physics with applications to the areas of electricity and magnetism. Topics include the measurement of electric and potential fields, RC decay, bridge networks, magnetic fields and the motion of charged particles. Prerequisite: 96-144. Corequisite: 95-243 or 95-245. Staff.

96-246 FUNDAMENTALS OF EXPERIMENTAL PHYSICS IV II (0,3) 1

A continuation of 96-245, but with applications principally to topics in modern physics. Experiments include studies in physical optics, atomic spectroscopy, photoelectric effect and nuclear decay. Prerequisite: 96-245. Corequisite: 95-246. Staff.

96-257 PHYSICAL INSTRUMENTATION I (1,3) 2

An introduction to measurement devices emphasizing practical physical applications. Both analog and difital electronic techniques are covered. Corequisite: 95-209 or equivalent. Smith.

96-293 EXPERIMENTAL PHYSICS I I (1,6) 3

A course in experimental methods of physics, with related theoretical material. Experiments are principally in the area of electrical measurements. Lectures are given on laboratory techniques and practices, and on the elementary theory of errors. The laboratory and lectures are integrated. Prerequisite: 95-144 or 95-148. Wong.

96-294 EXPERIMENTAL PHYSICS II II (1,6) 3

Continuations of 96-293. Experiments are principally in the areas of optics, thermodynamics, mechanics and atomic physics. Wong.

96-393 INTERMEDIATE PHYSICS LABORATORY I I (0,6) 2

Advanced experiments in various branches of physics including mechanics, optics and atomic physics. Prerequisite: 96-294. Mittler, Waldman.

96-394 INTERMEDIATE PHYSICS LABORATORY II II (0,6) 2

Advanced experiments in various branches of physics including solid state physics and nuclear physics, with opportunities for independent work by permission of the instructor. Mittler, Waldman.

Primarily for Graduate Students

96-593, 594 GRADUATE LABORATORY I-II I (0,9) 3; II (0,9) 3

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics. Prerequisite: permission of instructor. Ring.

DEPARTMENT OF RADIOLOGICAL SCIENCES

Radiological Health Physics (Course Prefix 98)

98-101 INTRODUCTION TO RADIOLOGICAL SCIENCES I (1,0) 1

Introduction to atomic and nuclear physics; natural and artifical radio-activity, radiation, decay schemes; nuclear reactions including fission and fussion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations. Prerequisite: radiological health physics major. Skrable.

98-102 INTRODUCTION TO RADIOLOGICAL SCIENCES II (1,0) 1

Principles of radiation detection and detection devices; counting systems and assay of α, β, γ, emitters; survey and monitoring equipment; external radiation exposure and protection techniques; radiation safety and control; accelerator and reactor health physics; medical radiation physics and X-ray protection. Prerequisites: 98-101, radiological health physics major. Skrable.

98-201 HEALTH PHYSICS INTERNSHIP I I, II (0,10) 3

Applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution. Prerequisites: radiological health physics major; 98-101 and 98-102; approval department chairperson. Chabot.

98-202 HEALTH PHYSICS INTERNSHIP I I, II (0,10) 3

Applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution. Prerequisites: radiological health physics majors; 98-201; approval department chairperson. Chabot.

98-301 HEALTH PHYSICS INTERNSHIP II I, II (0,10) 3

Applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital or education and research institution. Students in this course will be given increased responsibilities commensurate with prior experience. Prerequisites: radiological health physics major; 98-201 and 98-202, approval department chairperson. Chabot.

98-302 HEALTH PHYSICS INTERNSHIP II I, II (0,10) 3

Applied work experience as a health physics technician at a government laboratory or a radiation facility of some industry, hospital, or education and research institution. Students in this course will be given increased responsibilities commensurate with prior experience. Prerequisites: radiological health physics major; 98-202; approval department chairperson. Chabot.

98-401 PRINCIPLES OF RADIATION SAFETY AND CONTROL I (3,0) 3

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material. Prerequisite: 80-202 or equivalent. Skrable.

98-402 PRINCIPLES OF RADIATION SAFETY AND CONTROL II (3,3) 4

A laboratory course giving students experience with equipment and practices of current use in the radiation protection field, an extension of 98-401 giving some of the practical aspects of radiation safety and control. Prerequisite: 98-401. Skrable.

98-403 NUMERICAL LABORATORY IN RADIATION SAFETY & CONTROL (0,2) 1

Extensive problem solving with examples applicable to practical aspects of radiation safety and control. Use will be made of electronic calculators and/or computers in problem solutions. Corequisite: 98-401. Skrable.

98-412 RESEARCH IN RADIOLOGICAL SCIENCES I (0,10) 3

A research problem related to the field of radiation protection is investigated by the student under the direction of faculty and staff of the Nuclear Center. The student will present a seminar on his research project. Areas of reseach anticipated include radiation shielding, radiation detection and measurement, radiation survey and monitoring, radiation biology, radiation chemistry, radiobiology, radiochemistry, radioecology, natural radioactivity, fall out, analyses and measurement of radioactivity and radiation levels associated with the operation of reactors and accelerators, and radioactive aerosols. Prerequisites: senior status as radiological health physics major an approved proposal.

98-422 ENVIRONMENTAL RADIATION AND NUCLEAR SITE CRITERIA II (3,0) 3

Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, acquatic and terrestrial eco-systems; design and operation of environmental surveillance programs around nuclear facilities; reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations; environmental impact of nuclear reactors. Prerequsite: 98-401 or equivalent. Harris.

98-441 RADIOISOTOPE TECHNIQUES I (3,0) 3

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities. Prerequisite: senior status as biology major or equivalent background. Harris.

98-443 RADIOISOTOPE TECHNIQUES LABORATORY I I (0,3) 1

Laboratory experience in tracer techniques and appropriate use of various types of laboratory counting instruments. Corequisite: 98-441 or equivalent. Harris.

98-451 INTRODUCTION TO ELECTRONIC PRODUCT RADIATION I (3,0) 3

The theoretical and applied aspects of the generation, measurement, and uses of radiant energy from electronic products whose emissions span the entire electromagnetic spectrum; ultrasonic energy emitted by elecronic products; biological effects, standards of protection and control, and consequences and intent of Public Law 90-602. Prerequisite: 98-401.

98-461 SPECIAL TOPICS IN RADIOLOGICAL SCIENCES I (3,0) 3

This course is used to provide students with current information on a variety of current topics. Topics covered are announced prior to registration. Topics may vary from year to year. Prerequisite: senior status as radiological health physics major.

98-462 SPECIAL TOPICS IN RADIOLOGICAL SCIENCES II (3,0) 3

This course is used to provide students with current information on a variety of current topics. Topics covered are announced prior to registration. Topics may vary from year to year. Prerequisite: senior status as radiological health physics major.

98-502 RADIATION PHYSICS AND SHIELDING DESIGN II (3,0) 3

Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding of point, surface, and volume sources; shielding design factors in reactor and accelerator operation. Prerequisite: permission of instructor, Advanced Calculus, and graduate status as radiological sciences student, or equivalent.

98-503 INTRODUCTION TO RADIATION CHEMISTRY I (3,0) 3

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination. Prerequisite: permission of instructor. Not offered every year.

98-504 RADIATION PHYSICS AND SHIELDING LABORATORY II (0,3) 1

Laboratory coordinated with 98-501 with applications to health physics problems. Corequisite: 98-502. Not offered every year.

98-505 RADIATION DOSIMETRY I (3,3) 4

Sources of radiation exposure; calculations of chronic and acute radiation doses and their effects; internal dosimetry including distribution and elimination of radioisotopes; alpha, beta, gamma, and neutron dosimetry; principles of charge measurement and energy transfer; use and calibration of instruments including solid state dosimeters, ion chambers, and extrapolation chambers. Prerequisite: permission of instructor, and graduate status as radiological sciences student, or equivalent. Liuzzi.

98-507 RADIATION DOSIMETRY LABORATORY I (0,3) 1

Laboratory experience coordinated with lecture sequence in 98-505. Corequisite: 98-505. Not offered every year.

98-508 ENVIRONMENTAL TOXICOLOGY AND EPIDEMIOLOGY II (3,0) 3

Study of the systems of the body with respect to the sites and modes of action of various toxic agents. Discussion of procedures for evaluation of toxicity of radioactive and non-radioactive agents. Determination of TLV and LD_{50} values. Review of status of current epidemiology studies of effects of radiation and other toxic agents. Discussion of occupational environments with respect to standards, control measures, and current problems. Review of standards for protection of the environment and the general public. Prerequisite: graduate student with science background or permission of instructor. Offered odd-numbered years. Harris.

98-510 ENVIRONMENTAL TOXICOLOGY LABORATORY II (0,3) 1

Laboratory experiments on the effects of toxic agents on plant and animal systems with emphasis on radiation and air pollutants. Corequisite: 98-508. Offered in odd-numbered years. Harris.

ORGANIZATION AND GOVERNANCE

The College of Pure and Applied Science is organized into six departments and is administered by a dean, who is assisted by an all-college council. The six departments are responsible for developing course offerings and programs of studies. Although the faculty of the College has overall responsibility for all academic policies of the College, the Undergraduate Academic Standards and Curriculum Committee is responsible for enforcing the academic standards of the pure and applied sciences faculty and also serves as a review body for suspended students seeking readmission with probationary status.

UNDERGRADUATE ACADEMIC STANDARDS AND CURRICULUM COMMITTEE

Dr. George Carr, Physics and Applied Physics
Dr. Nelson Eby, Earth Sciences
Dr. George Griffin, Chemistry
Dr. Jessee Harris, Radiological Health Physics.
Dr. Ruth Tanner, Chemistry
Dr. Arthur Mittler, Physics and Applied Physics
Mr. Alan Doerr, Mathematics
Mr. Robert Gravina, Mathematics
Dr. Thaddeus Osmolski, Biological Sciences
Mr. Paul Protopapas, Biological Sciences

COLLEGE COUNCIL

Dr. Robert Coleman, Biological Sciences
Dr. Joseph Salamone, Chemistry
Dr. Gunter Kegel, Physics
Dr. Kenneth Skrable, Radiological Science
Dr. Arnold O'Brien, Earth Sciences
Mr. Alan Doerr Mathematics

BIOLOGY
LIFE ON EARTH
HUMAN PHYSIOLOGY
Ecology

FACULTY OF THE COLLEGE OF PURE AND APPLIED SCIENCES

DEAN OF THE COLLEGE

Dr. John Bruce, B.S., M.S., Ph,D.

DEPARTMENT CHAIRPERSONS

Dr. Robert Coleman, B.S., M.S., Ph.D.; Biological Sciences

Mr. Alan Doerr, B.A., M.A.; Mathematics

Dr. Kenneth Skrable, B.S., M.S., Ph.D.; Radiological Health Physics

Dr. Gunter Kegel, B. Phy., Ph.D.; Physics and Applied Physics

Dr. Arnold O'Brien, A.B., M.S., Ph.D.; Earth Sciences

Dr. Joseph Salamone, B.S., Ph.D.; Chemistry

INSTRUCTIONAL STAFF

Edward L. Alexander, Professor, Radiological Sciences, B.S., M.S., University of Maine; Ph.D., Vanderbilt University

Albert Altman, Professor, Mathematics; B.S., Brooklyn College; M.S., Ph.D., University of Maryland.

Donald L. Ameen, Assistant Professor, Physics; B.S., Lowell Technological Institute; M.D., Cornell University.

Leonard E. Andrusaitis, Assistant Professor, Mathematics; B.S., M.A., Boston College; C.A.G.S., Boston University.

Adolph Baker, Professor, Physics; B.A., M.S. Ed., City College of New York; B.M.E., Polytechnic Institute of Brooklyn; M.S., New York University; Ph.D., Brandeis University.

Edward F. Baldyga, Instructor, Mathematics; B.A., M.A., University of Connecticut.

Luther C. Barcus, Associate Professor, Physics; B.A., University of Delaware; M.S., University of Miami.

Barry K. Barnes, Associate Professor, Physics; B.A., M.A., Ph.D., Rice University.

Leon E. Beghian, Professor, Physics; B.A., Ph.D., University of Oxford.

Shimshom Berkovits, Assistant Professor, Mathematics;
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M.S., University of Chicago; Ph.D., Northeastern University.

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Ph.D., University of Strasbourg.

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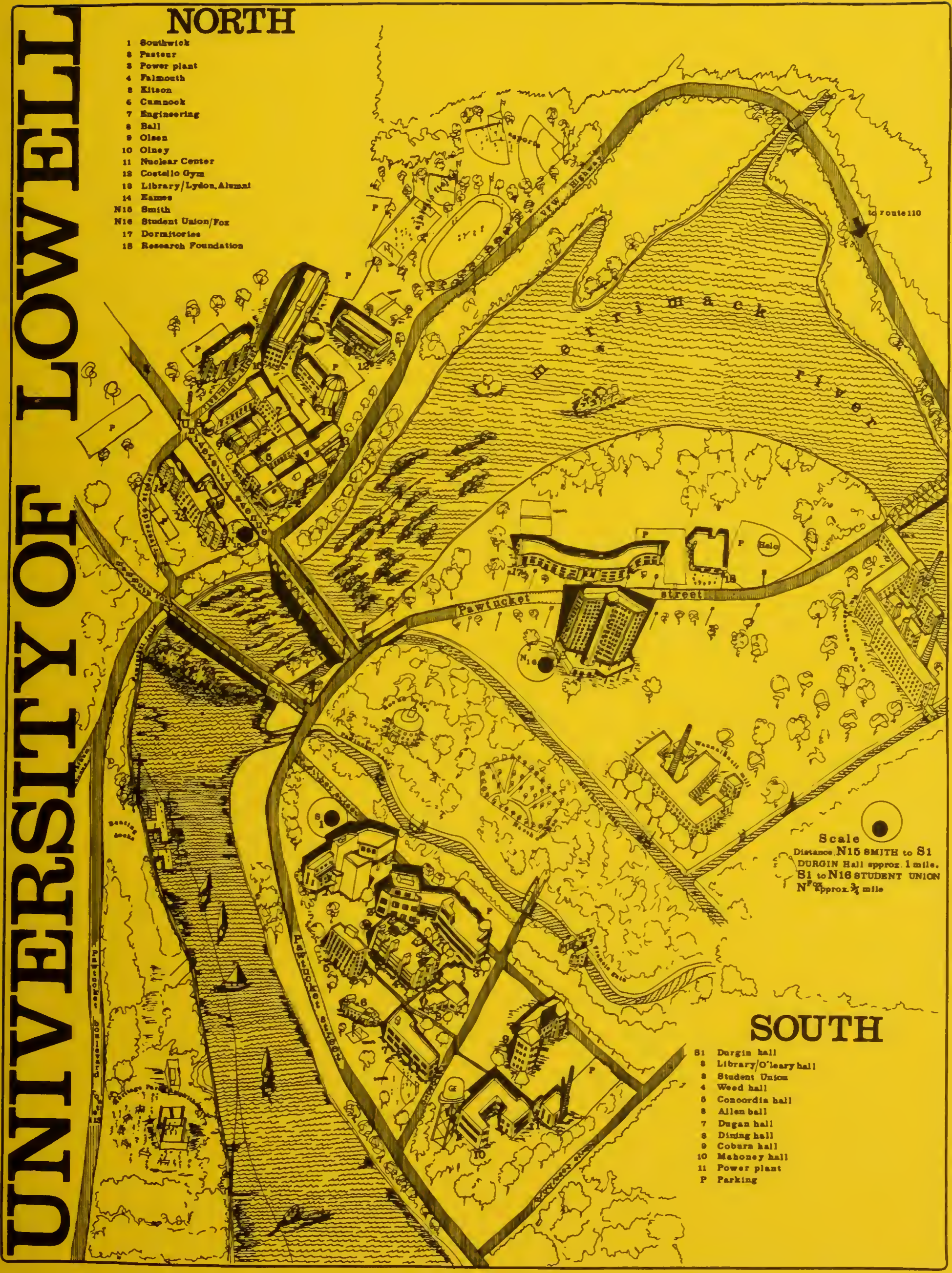

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